

A TEXT-BOOK OF PHARMACOGNOSY

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THIRD



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PREFACE TO THE THIRD EDITION

THE present edition has been thoroughly revised and enlarged to the extent of some 70 pages and 46 illustrations. Whilst the arrangement of drugs under plant families has been retained, the book has been divided into five instead of three parts by the separation of sections on microscopy, containing four new chapters, and on the analysis of drugs, containing a new chapter written in collaboration with Mr. H. O. Meek, Ph.C. The remainder of the text has been brought up to date and further illustrations added to it.

With the exception of Fig. 49, the block for which was kindly lent by Messrs. T. J. Smith and Nephew, Ltd., the sources of photographs and blocks are acknowledged in the text. I am indebted to Mr. A. W. Evans of Messrs. Southalls (Birmingham), Ltd., for help in connection with the chapter on surgical dressings, to Mr. J. Widliffe Peck for the use made of his article on the manufacture of cotton and to the Editor of the *Pharmaceutical Journal* for permission to reproduce passages from this and other articles. I desire to thank the numerous correspondents who have supplied information or made suggestions for the improvement of the book, Mr. J. C. Roberts for reading the manuscript and Miss M. I. J. Boyd and Mr. F. R. Mumford for checking the proofs.

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NOTTINGHAM.

October, 1938.

EXTRACTS FROM THE PREFACE TO THE FIRST EDITION

This book covers the requirements in pharmacognosy of students reading for pharmaceutical examinations in most English-speaking countries.

In addition to the contributors whose names are mentioned on the title page my sincere thanks are due to Miss E. M. Abbott, who has drawn or redrawn practically all the sketches and has assisted in the preparation of the index. I am indebted to my colleagues, Mr. A. O. Bentley, Ph.C., and Dr. J. E. Driver, M.Sc., A.I.C., for reading the manuscript, and, together with Mr. A. R. G. Chamings, B.Pharm., Ph.C., for checking the proofs; to Mr. R. J. Newman and Mr. W. Sutcliffe for the photography; and to Lieut.-Colonel W. R. Mansfield for kindly making me the luminograms reproduced in Figs. 43 and 44. Help on special points has been afforded by Mr. G. F. Sleggs, M.Sc., Mr. T. E. Wallis, B.Sc., F.I.C., Ph.C., Mr. E. J. Parry, B.Sc., F.I.C., Mr. A. T. Hall, Ph.C., and the late Mr. W. H. Martindale, Ph.D.

My thanks are due for the loan of photographs and blocks, the sources of which are acknowledged in the text, and to the Editors of the *Pharmaceutical Journal* and *Chemist and Druggist* for permission to reproduce certain passages from these journals.

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PART I
GENERAL PRINCIPLES

PHARMACOGNOSY

CHAPTER I

HISTORICAL INTRODUCTION

PHARMACOGNOSY may be defined as that science which deals with the investigation of crude drugs and other raw materials of vegetable and animal origin from all points of view excepting that of their medicinal action. The study includes their history, commerce, cultivation, collection, preparation for the market and storage; their chemistry and their identification and valuation both in the whole and powdered states. Since pharmacognosy is to a large extent a combination of economic botany, zoology, and plant chemistry, some knowledge of biology and organic chemistry is essential to a proper appreciation of the subject. The word "pharmacognosy" is derived from the Greek, *pharmakon*, a drug, and *gignosco*, to acquire a knowledge of. It appears to have been first used by Seydler in 1815 in a small work on drugs entitled *Analecta Pharmacognostica*. Within recent years the word pharmacognosy has largely replaced the term *materia medica* among pharmacists but not among medical men. While the terms have frequently been used as synonyms, the pharmacognosy taught in schools of pharmacy differs from the *materia medica* of the schools of medicine. The retention of both terms in their respective spheres seems desirable. *Materia medica*, in its widest sense, includes substances of mineral as well as animal and vegetable origin and embraces to some extent the study of therapeutics. Pharmacognosy, on the other hand, is concerned with drugs of animal and vegetable origin only, and although text-books on the subject usually include notes on the uses of each drug, no attempt is made to teach therapeutics.

HISTORY

The cultivation of plants for dietetic and medicinal use is of extreme antiquity. Linseed, for example, was cultivated in Egypt during the Stone Age, and poppy seeds have been found in lake dwellings. The date and barley have been cultivated from at least 5000 B.C., and an Assyrian clay tablet in the British Museum refers to a brown drug, "a daughter of the poppy," which is obviously opium.

Medicinal plant culture was encouraged by the Babylonian kings as early as 1940 B.C., and about 150 B.C. an Egyptian queen had a greenhouse erected for the cultivation of medicinal plants. In America terraces dating from Inca times testify to the early cultivation of coca, and coca leaves taken from an Inca tomb have been examined chemically and microscopically in recent years. The kings of the Montezuma line had gardens in which medicinal plants such as that yielding balsam of Peru were cultivated.

Mention must be made also of the early civilisations of Bactria, Babylonia, Assyria, and the Far East, the caravan routes by which their drugs and other commodities were carried, and of the extensive maritime interests of the Arabians and Phoenicians. From very early times Egypt and the Mediterranean countries received drugs by overland routes from as far away as China and by sea-routes from the coasts of Africa, India, and the Far East. During these long journeys the drugs usually passed through many hands, with the result that the consumers often found them very expensive and were frequently unaware of their country of origin.*

The great importance of spices in times when fresh meat was only available at certain seasons of the year was an important factor in stimulating rivalry between commercial nations, and encouraged exploration and subsequent European colonisation.

In the historical notes given under drugs in Part III of this book frequent reference is made to writers of antiquity. The following chronological list of some of the more important of these may be referred to as required. It must be emphasised, however, that a certain background of general history is essential to a proper appreciation of this aspect of the subject.†

* See historical notes on drugs such as Cinnamon, Cassia, Camphor, Cardamoms, and Grains of Paradise, in Part III.

† For an elementary account students will find all they require in *A Short History of the World*, by H. G. Wells, and *The British Empire since 1783*, by

Susruta, ca. 500 B.C. Author of the Sanskrit medical work, *Ayurvedas*.

The Greek and Roman Periods.—*Hippocrates*, ca. 459–370 B.C. The most celebrated physician of Greek antiquity. The Hippocratic writings number about 60. He was familiar with drugs such as cinnamon, hemlock, gentian, rhubarb, and myrrh, but relied very largely on attention to diet and regimen. Hippocrates was sometimes reproached for over caution in treatment.

Theophrastus, 371–287 B.C. A Greek moralist and naturalist, and a pupil of both Plato and Aristotle. His *Historia plantarum* and *De Causis plantarum* are the earliest European writings on plants.

Alexander the Great, 356–323 B.C. A Greek conqueror of Syria, Persia, Egypt, and part of India. His activities greatly extended European knowledge of geography and natural history, and his founding of Alexandria with its library (331 B.C.) was instrumental in preserving many of the ancient writings.

Celsus, ca. 25 B.C.–A.D. 50. A physician and writer who was largely instrumental in introducing the Hippocratic system of medicine to the Romans. In his chief surviving work, *De Medicina*, some 250 drugs are mentioned and a valuable account is given of the surgery of the period.

Scribonius Largus. A Roman physician who accompanied Claudius in A.D. 43 in the attempted conquest of Britain. His collection of recipes, *Compositones Medicamentorum seu Compositones Medicæ*, indicates the drugs then in common use.

Dioscorides. A Greek born in Asia Minor during the first century. He accompanied the Roman armies and visited Syria, Italy, Spain, and Africa. His *De Materia Medica*, written about A.D. 77, was a very complete work on drugs of vegetable, animal, and mineral origin. It embraced more than 500 drugs, gave notes on collection, preservation, and adulteration, and was profusely illustrated. For fifteen centuries Dioscorides remained the great authority on botany and materia medica. His work was translated into Arabic, Italian, French, and Spanish.

Pliny or *Plinius*, A.D. 23–79. A native of northern Italy whose military duties took him to Germany and Spain. On his return to Rome in A.D. 52 he was received by the Emperor

A. P. Newton and J. Ewing. The history of drugs is more fully dealt with in the *Pharmacographia* of Flückiger and Hanbury, and the *Handbuch der Pharmakognosie* of A. Tschirch.

Vespasian as a personal friend. In spite of many commissions undertaken for the Emperor, Pliny found time for extensive study. Of all his numerous works only the *Historia Naturalis*, in 37 volumes, has come down to us. This is concerned with all the natural sciences, and contains, as the preface states, 20,000 matters of importance (including about 1,000 plants) extracted from about 2,000 volumes. While in command of the Roman fleet in A.D. 79 he landed to view the eruption which submerged Herculaneum and Pompeii, and, being in indifferent health, died as a result of exposure to the fumes, although his attendants escaped.

Galen, A.D. 131-200. A Roman physician and a voluminous writer. Although usually remembered by pharmacists for his books of recipes and by the word "galenical," his anatomical and physiological work was of great importance. He frequently recommends the dissection of animals,* and was an authority on the pulse. Before the time of Galen there were many different medical sects, but these gradually merged in his followers who, in the period of Roman decline, added little or nothing of scientific importance. Galen's works were translated into Arabic in the ninth century, and his views were long considered infallible.†

The Arabian Period.—The Arabs showed little interest in learning during their period of conquest, which during and following the life of Mahomet (570-630) had by 710 given them territory extending from India and Turkestan on the east, through Egypt and North Africa to Lisbon on the west. Subsequently, however, the arts and sciences were encouraged, particularly by Almansor (754-775), Harun-al-Raschid (786-808), and Al-Mamun (813-833). Schools were founded in Bagdad, Basra, Bokhara, Kufa, and Cordova, and libraries were collected at Bagdad, Alexandria,‡ and Cairo. Medicine advanced except in anatomy.§

* It is probable that his experiments were confined to animals, but he mentions that those physicians accompanying the armies against the Germans had the opportunity of dissecting the bodies of the barbarians.

† In the records of the London College of Physicians it is shown that a Dr. Geynes in 1559 "was cited before the college for impugning the infallibility of Galen. On his acknowledgment of his error, signed with his own hand, he was received into the college."

‡ The original Alexandrian library suffered by fire during the siege by Julius Caesar. It was partly restored by donations given to Cleopatra by Mark Antony. That part of the library stored in the heathen temple of Jupiter Serapis suffered at the hands of a Christian mob in A.D. 391. Further destruction was wrought by the Arabs.

§ The Koran forbids the dissection of bodies.

Geber, ca. 700-765. Founder of the Arabian school of chemistry or alchemy.* His writings show a knowledge of the preparation of common metals, salts, acids, and alkalis, and of the processes of filtration, crystallisation, sublimation, and distillation.

Rhazes, 865-925, and *Avicenna*, 980-1037, were two of the more famous Arabian physicians. They did much to transmit to posterity a knowledge of Greek and Roman medicine, and introduced drugs of Arabian and Indian origin.

Ibn Baitar, 1197-1248, travelled from Spain to Egypt, where he spent the last ten years or so of his life at the Egyptian Court. His *Liber magnæ collectionis simplicium alimentorum et medicamentorum* was an important contribution to materia medica, most of the descriptions of drugs showing evidence of personal observation.

Marco Polo, 1254-1324, though not an Arab, may be mentioned here. This celebrated Venetian traveller spent twenty-five years in Asia (1271-1295). On the outward journey he travelled by a devious overland route, but on the return journey went by boat to Persia. While acting as ambassador to Kublai Khan he visited India and the East Indies.†

Ibn Batutah, 1303-1377. A celebrated Arabian traveller born in Morocco. He visited the Caspian regions, also Delhi, Java, and Peking, and penetrated Africa as far as Timbuctoo.

The European Period.—The oldest Anglo-Saxon book on herbs is the Leech Book of Bald, which dates from about 900 to 950. The Anglo-Saxons had names for and used at least 500 plants, a far greater number than appears to have been used by continental nations of the same period.

By the twelfth century a medical school, the first to grant regular diplomas, had been established at Salerno near Naples. The drugs used there are described in the *Alphita*.

Arabian influence, particularly in Spain, led to the spread of alchemy, which is associated in Europe with the names of *Roger Bacon* (1214-1294), *Albertus Magnus* (1193-1280), and *Paracelsus* (1493-1541). The latter introduced into medicine alcoholic preparations, compounds of lead and antimony, and "vitriols." He was strongly opposed to the "shot-gun"

* For an account of the subject of alchemy one of the several histories of chemistry should be consulted.

† *The Travels of Marco Polo the Venetian*, No. 306 of J. M. Dent & Sons, Ltd., "Everyman's Library."

type of prescription favoured by the Arabs, and advocated the use of simples. The "doctrine of signatures," or the belief that the form of each plant indicates its medicinal virtue, is usually associated with the name of Paracelsus, but its greatest advocate was *Giambattista Porta*, who in 1588 published *Phytognomonica*.

During the early Middle Ages medicinal plant culture was largely confined to monastery gardens, but with the establishment of universities in the twelfth, thirteenth, and fourteenth centuries a number of other herb gardens made their appearance.

The discovery of new lands and of fresh routes led to the introduction of many new drugs. Many of these were studied by *Monardes* (1493-1578) and *Carolus Clusius* (1526-1609). Our present knowledge of drugs has been built up by the work of explorers, traders, botanists, chemists, and pharmacognosists. Some of these are mentioned in the following chronological table, which also attempts to indicate the extent and varying fortunes of European attempts at colonisation.

- | | |
|---------|---|
| | 1470 Herbal of Bartholomæus Anglicus. |
| | 1484 The Latin Herbarius. |
| | 1485 Herbarius zu Teutsch. |
| | 1491 Ortus Sanitatis from the School of Salerno. |
| 1486 | Diaz rounded the Cape. |
| 1493 | Columbus returned from his first voyage to the New World, having discovered San Salvador. On his two subsequent voyages explored the West Indies and the North Coast of S. America. |
| 1494 | Division of new territories by the Pope between Spain and Portugal. |
| 1498 | Vasco da Gama sailed round the Cape to India. |
| 1511-18 | Portuguese in India (Goa), Ceylon, Spice Islands, Java, and Sumatra. |
| 1519 | Mexico conquered by Cortes. |
| 1529-35 | Chili and Peru conquered by Pizarro. |
| 1530 | Herbal of Otto von Brunfels. |
| 1533 | Padua herb garden founded. |
| 1542 | Herbal of Leonhard Fuchs. |
| 1544 | Florence and, 1547, Bologna herb gardens founded. |
| 1551 | Wm. Turner's Herbal. |

HISTORICAL INTRODUCTORY

- 1569-74 Monardes^{*} published.
 1570 Book by Paracelsus on drugs, metals, etc.
 1577 John Frampton's translation of Monardes.
 1597 Herbal of John Gerarde.
 1629 Herbal of John Parkinson.
 1632 Oxford herb garden founded.
 1652 Herbal of Nicholas Culpepper.
 1673 Chelsea herb garden founded.
 1675 Edinburgh herb garden founded.
 1694 Pomet's *Histoire Générale des Drogues*.
 1697 Lemery's *Traité Universel des Drogues Simples*.
 Linnæus, 1707-88.*
 Scheele, 1742-86.†
 Pereira, J., 1804-53.†
 Merck, H. E., 1794-1853.†
 Lindley, J., 1799-1865.*
 Berg, O. K., 1815-66.*
 Fischer, E., 1852-74.†
 Hanbury, D., 1825-75.†
 Schleiden, M. J., 1804-81.*
 Wöhler, F., 1800-82.†
- 1577-79 Drake sailed round the world.
 1580 Philip II united Spain and Portugal.
 1588 Spanish Armada defeated.
 1600 East India Company formed. Forts built in Java, Amboyna, and Banda.
 1615 Bermudas settled.
 1620 Pilgrim Fathers founded New Plymouth. First negro slaves landed in America.
 1652 Dutch founded a station at Table Bay.
 1658 Ceylon taken from the Portuguese by the Dutch, who seized other Portuguese and British possessions.
 1674 Nieuw Amsterdam became British by treaty and was renamed New York.
 1755-63 Britain and France struggled for America and India.
 1768 Capt. Cook's first voyage to New Zealand and Australia.
 1776 Independence of the U.S.A. declared.
 1786 Penang acquired by the E.I. Company.
 1788 Warren Hastings impeached.
 1795 The Cape occupied by Britain and in 1814 annexed to the British Empire.
 1819 Singapore obtained from the Sultan of Johore.
 1833 Abolition of slavery. The opening of the China ports and cessation of the East India Company's charter led to free and increased trade in India.

* Botanist.

† Chemist.

‡ Pharmacognosist.

- 1839 Aden brought under British rule.
- 1841-42 J. Brooke appointed Rajah of Sarawak.
- 1842 Britain obtained cession of Hong-Kong.
- 1857 Indian Mutiny.
- 1858 Property of the East Indian Company transferred to the Crown.
- 1869 Suez Canal opened.
- 1877 Annexation of the Transvaal.
- 1887 Annexation of Zululand.
- 1899-1902 South African War.
- 1915 Panama Canal opened.
- 1920 First meeting of League of Nations. Mandates set up. Syria, Togoland, and Cameroons placed under the control of France; Mesopotamia ('Iraq) and German East Africa (Tanganyika) under Britain; German S. W. Africa under the Union of South Africa; and territories in the Pacific under Australia and New Zealand.
- Howard, J. E., 1807-84, H.M. 1883. §
- Maisch, J. M., 1831-93, H.M. 1893.
- Hesse, J. O., b. 1835, H.M. 1891.
- Flückiger, F. A., 1828-94, H.M. 1881.
- Dragendorff, J. G. N., 1836-98, H.M. 1885.
- Dymock, W., d. 1892, H.M. 1887.
- De Vrij, J. E., 1813-98, H.M. 1897.
- Planchon, F. G., 1833-1900, H.M. 1889.
- Watt, G., 1851-1930, H.M. 1901.
- Martindale, W., 1841-1902. †
- Vogl, A. E., 1833-1909, H.M. 1895.
- Ladenburg, A., 1842-1911, H.M. 1899.
- Strasburger, E., 1844-1912.*
- Hartwich, K., 1851-1917. †
- Collin, E., 1849-1919, H.M. 1903.
- Solereder, 1860-1920.*
- Schmidt, E. A., 1845-1921, H.M. 1905.
- Mayer, A., 1850-1922. †
- Moeller, J., 1848-1923.*
- Kraemer, 1868-1924. †
- Power, F. B., 1853-1927, H.M. 1913.
- Brandt, A. W. H., 1879-1929. †
- Holmes, E. M., 1843-1930, H.M. 1915.
- Engler, A., 1844-1930.*
- Thoms, H. F. M., 1859-1931, H.M. 1931.
- Greenish, H. G., 1855-1933, H.M. 1917.
- Hooper, D., b. 1858, H.M. 1907.
- Tschirch, A., b. 1856, H.M. 1909.
- Léger, E., H.M. 1911.
- Oesterle, O. A., b. 1866. †
- Perrot, E., b. 1867, H.M. 1922.
- Henry, T. A., b. 1873, H.M. 1927.
- Rusby, H. H., b. 1865, H.M. 1929.
- Barger, G., b. 1878, H.M. 1933.
- Pyman, F. L., b. 1882, H.M. 1935.
- Wasicky, R., b. 1884, H.M. 1937.

* Botanist. † Pharmacognosist.

§ The abbreviation H.M. indicates Hanbury Medallist. On the death of the eminent pharmacognosist Daniel Hanbury, in 1875, a fund was raised to establish a memorial. The memorial takes the form of a gold medal which is given periodically for "high excellence in the prosecution or promotion of original research in the Chemistry and Natural History of Drugs." As will be seen from the above table the medal has been awarded to workers on the Continent and in America as well as to those of the British Empire.

CHAPTER II

LONDON COMMERCE IN CRUDE DRUGS

FROM the fact that at a very early date Phœnician traders visited England it may be surmised that the drugs of Egypt and the East were occasionally brought here. As early as A.D. 61, Tacitus, a Roman historian, described London as "crowded with traders and a great centre of commerce."* Small ships found good anchorage at the Pool, that part of the Thames immediately below the present London Bridge and the site of earlier bridges. During the Middle Ages, Venetian and Genoese ships arrived regularly, landing some of their merchandise at a point on Thames Street called Galley Key. In the thirteenth century the Hanseatic League, a great commercial confederacy, had offices commonly known as the "Steel Yard," in Thames Street. During the Middle Ages the Guild of Pepperers, which was afterwards merged into the Grocers Company, included dealers in drugs.† The first Navigation Act (1381) prohibited the carrying of merchandise to England except in English ships or in ships of the nation

* For much of the information contained in this chapter the writer is indebted to articles in the *Chemist and Druggist*. Further details may be found in "London's Drug Market and the Romance of Mincing Lane," *C. and D.*, 1928, 1, 851, and "London, the Drug Centre of the World," *C. and D.*, 1933, 1, 699. The illustrations are made from photographs taken in 1933, which were kindly supplied by the Editor of the *Chemist and Druggist*.

† *C. and D.*, 1928, 1, 855. "The earliest ordinances with which we are acquainted are those which they made with the assent of the Lord Mayor and Aldermen, in 1315-16, wherein they are described as the 'good folk of Sopers Lane of the trade of Pepperers.' They are arranged under four heads, viz. : (1) That no one of the craft shall directly or indirectly mix or adulterate goods of different quality and price ; (2) that no one shall tamper with bales, so as to change or transfer the contents of any bale, or place false names beneath true ones ; (3) that no one shall moisten saffron, alum, ginger, cloves, and such other merchandise in order to increase weight ; (4) that every vendor shall have true uniform measures and weights, shall sell by the hundredweight of one hundred and twelve pounds, fifteen ounces to the pound, save confections and powdered goods, which shall be sold by twelve ounces to the pound. This shows that prior to their combination with the Spicers, under the name of Grocers, the Pepperers had in use both the avoirdupois and troy or trou weights."

to whom the merchandise belonged, and further navigation and trade Acts in the seventeenth and eighteenth centuries, by reserving the colonial trade for English ships, did much to increase our maritime trade. During the reign of Elizabeth (1558-1603) the London Stock Exchange was opened, the East India Company received its Charter, and great improvements were made in the Thames quays.



FIG. 1.—Unloading at No. 2 London Dock (*Chemist and Druggist*.)

Mincing Lane and Mark Lane, which then led down to the water front, gradually became commercial centres inhabited by merchants and brokers. Commercial transactions were carried out in the numerous coffee-houses, the fore-runners of Lloyd's, the Stock Exchange, and the Baltic and Shipping Exchange. The Jerusalem Coffee House was famous as a meeting-place for those engaged in Eastern trade, and the Jamaica Coffee House as a resort of West Indian merchants.

Early Drug Sales.—Drug auctions were held at irregular intervals by the East India Company from its foundation in 1600, but regular quarterly auctions were first instituted in 1704.* Garraway's Coffee House, where the first tea was sold retail in 1657, and where drugs were sold "by the candle" for nearly two hundred years, was demolished in 1866. In 1811 the first London Commercial Sale Rooms were founded in Mincing Lane. The accommodation provided did not meet with general approval, and the absence of a place for refresh-

ments in close proximity soon caused the druggists to move their sales to the New Corn Exchange Tavern, and the Commercial Sale Rooms were long referred to as "Marten's Folly."

* An illustration of one of the East India Company's auctions in progress will be found in the *C. and D.*, 1928, 1, 850.

The present London Commercial Sale Rooms were built in 1890, and the drug sales have been held there since 1898.

London Docks.—By the eighteenth century lack of moorings and warehouse accommodation were being acutely felt on the river. The West Indian Docks were built and opened in 1802 and the construction of other docks rapidly followed. Competition between the various dock owners gradually led to an unsatisfactory state of affairs, and uneconomic rates for berthing, landing and storing. In 1908 the Port of London Authority was established to administer all the docks as a single unit. At the present time the P.L.A. controls docks covering an area of over 4,000 acres, with a water area of over



FIG. 2.—A corner of a drug warehouse (*Chemist and Druggist*).

700 acres. Quays, for unloading, have a total length of about 45 miles, and are well supplied with cranes and other appliances for handling cargo. As far as drugs are concerned, the London Dock and the St. Katharine Dock are the most important. These have a total area of about 45 acres and about 4 miles of quays. As they are situated well up the river, on the north bank, near the Tower, many of the incoming vessels discharge their cargoes into lighters and do not come up as far as these docks. Many drugs are also unloaded at the South-Eastern Wharf and Mark Brown's Wharf, on the opposite side of the river.

The Dock and City Warehouses.—After unloading, the

drugs are placed in warehouses, which are situated either in the docks or in the City. Each warehouse is in the charge of a foreman who is an expert in the storing, grading, sampling, packing and dispatching of the drugs placed in his care.

Owing to the wide range of qualities of drugs such as cardamoms, vanilla, and tragacanth, these are usually consigned for sale on the London market. Many drugs are, however, sold outright prior to dispatch.* Buying "forward" on a c.i.f. basis (*i.e.* at a price which includes carriage, insurance, and freightage) is now much more common than in pre-war days, but has not proved altogether satisfactory.† There is

* *C. and D.*, 1933, 1, 701, "For some years shippers have been disinclined to send much of their goods to this market on consignment. Uncertain conditions, fluctuating exchange rates, and the general fall in commodity values have all been factors which have tended to make shippers endeavour to sell their goods outright prior to shipment and, moreover, to sell direct to America and the Continent, rather than use London as a distributing centre."

† *C. and D.*, 1928, 1, 864: "The growth of the c.i.f. business in recent years is remarkable, and if one refers back to the Trade Report of the *C. and D.* of pre-war days there are only a few articles that bear a c.i.f. quotation. How different is the present-day system of trading! We find drugs like Sumatra benzoin, dragon's blood, ipecacuanha, gamboge, etc., which buyers in former days would have been afraid to purchase even on sample, and were never sold except after 'inspection in bulk,' are to-day freely disposed of for forward shipment or delivery on either a standard sample or a 'fair average quality' basis. The result is obvious, as practically every other shipment made brings with it claims for inferior quality, and the consumer finds himself forced to accept an article the quality of which is frequently useless for his requirements, and is granted an allowance as compensation for his loss. A buyer will, therefore, find himself compelled to accept an article for which he may have no use, and is forced to purchase, at a much higher price, the quality he requires from a holder of spot stocks."

"The number of arbitrations which take place to-day on Mincing Lane in practically every commodity of general produce is one of the most important arguments against the c.i.f. contract. Whereas, before the war, an arbitration was considered in the light of a definite and serious business dispute between two parties who were unable to arrive at a mutual understanding, to-day it is regarded by many as the chief loophole through which they can escape from a bad or unsatisfactory purchase. A produce broker of any important standing seldom seeks to act as an arbitrator, as besides the time involved and the difficulties that may arise, it is not infrequent that he may find himself penalised by one or other of the disputants for having the honesty of purpose in giving an award which may not please the party for whom he is acting. It is of interest to point out that the General Produce Brokers' Association of London is responsible for the appointment of a panel of arbitrators—all produce brokers—the selection of which is usually left to the parties to the dispute—one for each side. An umpire is only appointed when two arbitrators are unable to agree on a decision, the award of the umpire being made after hearing the arguments of both arbitrators. The award of the umpire is not final, as in the event of either party to the dispute being dissatisfied with a decision, he is at liberty to take his case to a special tribunal known as the 'Court of Appeal,' who reopen the case and make a final award after hearing all the parties to the dispute, including the arbitrators.

much to be said for the older system of examining either original packages in the warehouses or dock-drawn samples before buying. As a result of forward buying and the tendency for drugs to be sent direct to America and the Continent, the quantities of drugs offered at the drug auctions is smaller than was formerly the case.

Some examples of the work undertaken in the London warehouses may now be given. Considerable stocks of most drugs are held in London. Those which are liable to customs duties may be kept in bond until required. In the case of



FIG. 3.—Repacking gums after inspection (*Chemist and Druggist*).

cascara bark it is well known that the value increases with age. In order that there may be no question of the age of a particular sample, it is usual for the fresh-season bark to be imported when its age can afterwards be ascertained without question by the package number and date of importation. Certain drugs require to be garbled,* *i.e.* freed from dust and

This last award is binding on all parties, and the case cannot be reopened except in the law courts. It is estimated that on contracts where quality alone is a dominating factor, at least one in three is arbitrated upon."

* In the reign of James I an Act was passed making garbling compulsory in the case of spices and certain drugs. The work was undertaken by the King's garbler or his authorised deputies.

other impurities. In other cases, *e.g.* tragacanth and cardamoms, the original containers are emptied and the drug mixed (bulked), graded and repacked. These operations are known as "working" the drug. Such drugs as cinnamon are

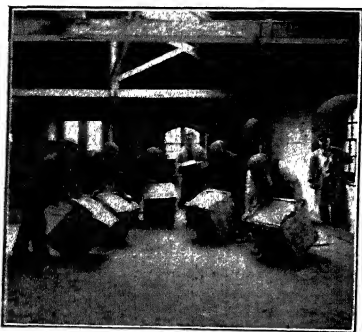


FIG. 4.—Preparing to bulk cardamoms
(*Chemist and Druggist*).



FIG. 5.—Cardamoms in bulk (*Chemist and Druggist*).



FIG. 6.—Taking a sample of turmeric
(*Chemist and Druggist*).



FIG. 7.—Opening a case of senna pods
(*Chemist and Druggist*).

carefully graded abroad, but the packages are nevertheless opened to see that the drug is in good condition and of constant quality throughout. In recent years London importers have suffered to some extent from the fact that the P.L.A. charges

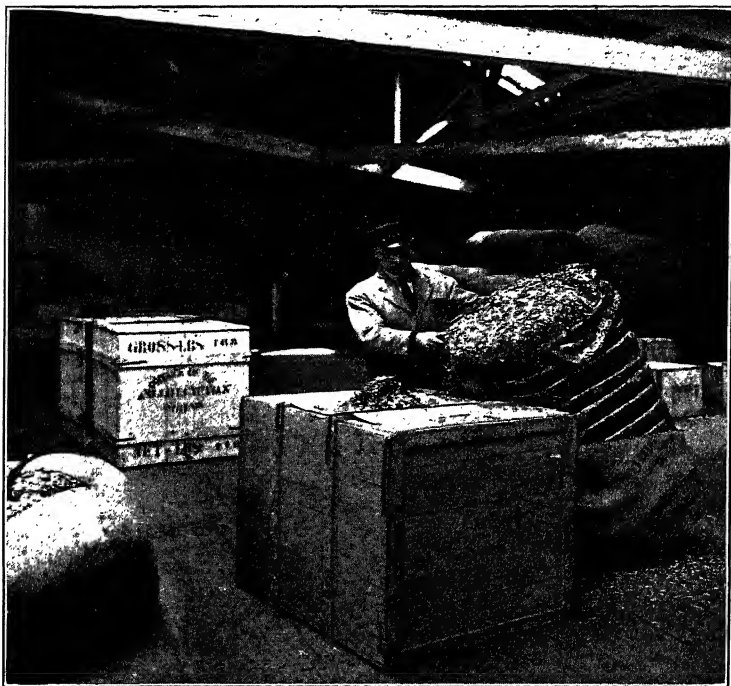


FIG. 8.—Sampling senna leaves (*Chemist and Druggist*).

for unloading, storing, and working drugs have been higher than those ruling at Hamburg, Antwerp, and other Continental ports.

Sampling is another important duty of the warehousemen.*

* *C. and D.*, 1928, 1, 866: "On one important point London still holds command, and that is in the general sampling of produce. A London dock or wharf sample is still recognised by the commercial community in any port of the world as unquestionable for its fairness, and whereas in any other country a sample has to be drawn by a representative of both the buyer and the seller, a sample drawn by a London wharfinger or the Port of London Authority is sufficient to satisfy the most fastidious of arbitrators."

Dock samples are often taken of such drugs as turmeric (Fig. 6), senna (Figs. 7, 8), honey, cassia pods, guaiacum resin, quince seeds, ipecacuanha root, and balsam of Tolu. To

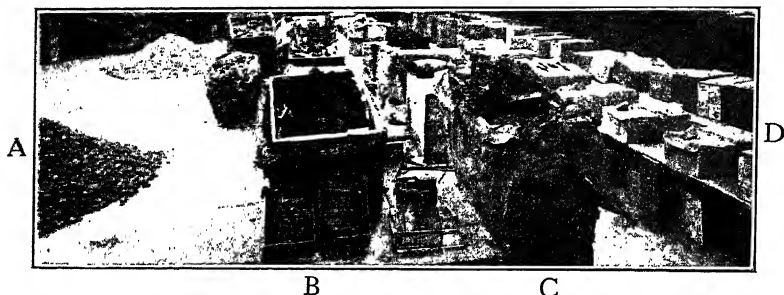


FIG. 9.—Drugs on show in No. 2 Warehouse. A, myrrh; B, vanilla pods with dragon's blood behind; C, Zanzibar aloes in skins; D, benzoin.

obtain a representative sample of, say, ipecacuanha, the bales are cut open and a half-pound sample taken from the top, middle, and bottom of each bale. Tins of balsam of Tolu are

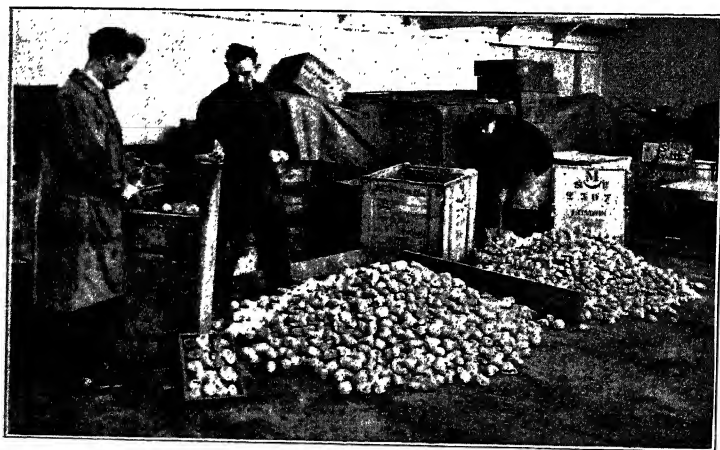


FIG. 10.—Splitting Shensi rhubarb (*Chemist and Druggist*).

sampled by means of a sampling iron, and the samples bulked to obtain an average.

The City or Cutler Street Warehouses are situated near Mincing Lane and Bishopsgate Goods Station. Here drugs such as aloes, benzoin (Fig. 9), sarsaparilla, ipecacuanha, dragon's blood, gamboge, rhubarb, and balsams may be examined by prospective buyers before the drug auctions.

Many of the above drugs are graded before being exhibited. Rhubarb, for example, is bulked, separated into "piles," and

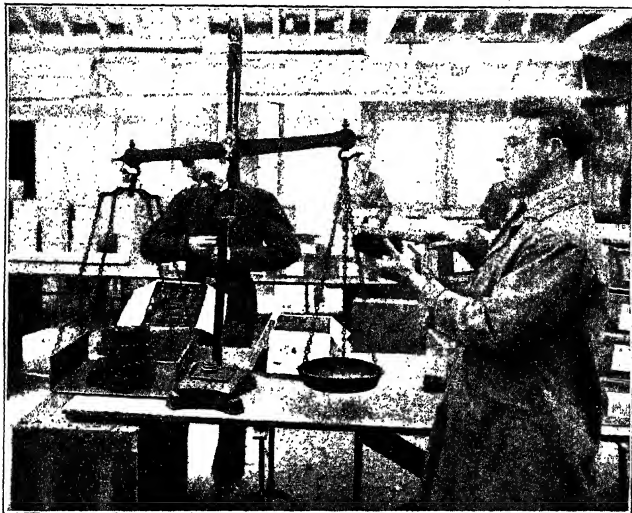


FIG. 11.—Grading Madagascar vanilla pods (*Chemist and Druggist*).

a sample of each pile fractured to show the condition of the interior (see Fig. 10). A special room is devoted to the storage and grading of vanilla pods (see Fig. 11).

The methods of drug brokers and buyers when examining drugs appear to be somewhat crude when judged by scientific standards although they work well in practice. It is nevertheless amusing to watch a buyer test dragon's blood by grinding it under his heel, and to find that such drugs as ipecacuanha are often bought without any knowledge of the alkaloidal

content. In some cases, however, analyses are regularly made, *e.g.* opium and cinchona. The price of these drugs is often worked out on the basis of morphine and quinine units. Although cinchona bark is sold in London, Amsterdam is a far more important centre for this drug. *Strophanthus* seeds are generally guaranteed by an independent analyst to be 100 per cent. genuine kombé. Other analytical results, such



FIG. 12.—Examining dock samples of senna in the offices of John Ronaldson & Co., of Seething Lane (*Chemist and Druggist*).

as alkaloidal contents and the ash values of drugs (*e.g.* kamala), are guaranteed in a similar manner.

The Brokers' Sale Rooms.—The various firms of drug brokers have offices and sale rooms in or around Mincing Lane. Their names appear on the sales catalogue shown in Fig. 13. These firms sell drugs, and often other things, such as tortoiseshell, varnish gums, rubber, ivory, mica, isinglass, shellac, bristles, etc., on commission. Drugs which are consigned to

ORDER OF DRUG SALES. PAINES & REID
18/11/32.

1 LEWIS 4 SLANE
2 DALTON 7 FIOGINS
3 FRENCH 8 HALE
4 BARTWOOD 9 PAINES
5 TOLLEY

FOR

AT THE

LONDON COMMERCIAL SALE ROOMS

MINING LANE.

ON

Thursday, NOV. 23rd, 1933

At Half-past TEN o'Clock precisely.

Samples at 25, Mining Lane, E.C. 3

85 Barrels } HONEY
17 Kegs }
3 Cases DRAGONS BLOOD
62 Cases SUMATRA GUM BENJAMIN
8 Bales MATTOGROSSO IPECACUANHA
55 Cases CURACOA ALOES
16 Sercons HONDURAS SALSAPARILLA
4 Bags GUM MYRRH
80 Bags CARNATUBA WAX
13 Cases WHITE CALOUTTA WAX
3 Cases CAPE ALOES
9 Bales BUCHA LEAVES
40 Bags LIQUORICE ROOT
67 Bags CROTON SEED
22 Bags KAMALA POWDER
6 Bales CARDAMOM HUSKS
40 Bags BRAZILIAN ANNATTO SEED
26 Bags MADRAS ANNATTO SEED
19 Cases CHAULMOOGRA OIL
11 Bags STROPHANTHUS SEED
6 Cases GUM TRAGACANTH
105 Bags NUX VOMICA
1 Tin GUM GALBANUM
30 Bags TURMERIC
8 Bags ORANGE PEEL

On Show at Gaffer Street Warehouse.

5 Cases RHUBARB
3 Cases BALSAM TOLU
6 Cases GUM MYRRH

New Conditions as printed 16th January, 1931, and Public Sale Conditions
as arranged and published by the General Produce Brokers' Association.

Goods sold at re-weights to be in
12 December, 1933, or they will be re-weighed at the Buyer's risk

52 Bags Kamala Powder, @ per lb.

Lying at London Docks.

Per Lahore, @ Calcutta.—October, 1932

Salmon & Sealer's Analysis 5 per cent. Ash.

A
B 56 12/16

6 Bales Cardamon Husks, at per lb.

Lot 57 IN BOND.

Lying at London Docks.

Per Ulan MacBride—July, 1933.

SIPC. 57 6/12 Cts. 3

40 Bags Brazilian Annatto Seed,
at per lb.

Lots 58 IN BOND.

Lying at London Docks.

Per Siris, @ Rio de Janeiro.—33/9825.

58 1/10 Bag 10 Cts. 1
(20 more)

26 Bags Madras Annatto Seed,
at per lb.

Lying at Metropolis Wharf.

Per Chan Morrison, @ Madras.—33/1137

WACO 10 11
ANN 60 11/26 16 Bales

19 Cases Chaulmoogra Oil at per lb.

Lying at London Docks.

Per Kisto, @ Cochin. September, 1933.

SA 61 7/11 Cases 5 Cts. 2 tins
London (14 more)

11 Bags Strophanthus Seed, at per lb.

Lying at 2nd Lion Wharf.

Per Madras, @ Beira. January, 1933.

Salmon & Sealer's Analysis. 100 per cent. Kumbha.

JCO 62 1/4 Bags 105 Cts.

FIG. 13.—The front and one of the inner pages of a typical drug-sale catalogue.
Original about 17 inches long.

London are placed in the brokers' hands and may be sold by him privately or offered at the bi-monthly drug auctions. Dock samples may be inspected at the brokers'. While brokers are usually prepared to offer any drug, a certain amount of



FIG. 14.—A drug show at French and Plucknett's, Mincing Lane (*Chemist and Druggist*).

specialisation is to be found. Certain brokers, for example, specialise in important lines such as senna, honey, ipecacuanha, and eucalyptus oil.

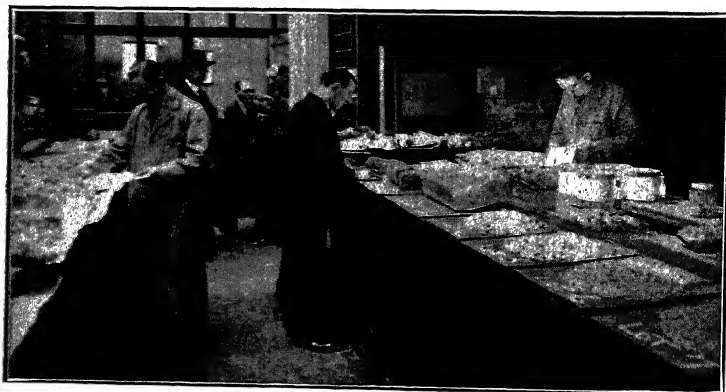


FIG. 15.—A drug show at Dalton and Young's, Fenchurch Street (*Chemist and Druggist*).

Before each drug auction catalogues are issued by the brokers. On the day immediately preceding a drug auction prospective buyers examine either dock samples in the brokers' offices or original packages in the Cutler Street Warehouse. The close proximity of the broker's offices to one another and to the Cutler Street Warehouse makes it quite easy for a buyer to see all he requires in a relatively short time. At these "drug shows," as they are called, the buyer notes those lots for which he is prepared to bid and the price he is prepared to give for each.



FIG. 16.—A drug show at Slann and Davies, Mark Lane (*Chemist and Druggist*).

The Drug Auctions.—In the London Commercial Sale Rooms public auctions take place almost daily of commodities such as tea, coffee, cocoa, wines, and spices. In pre-war days the drug auctions were held regularly every fortnight, but they are now held every other month. Each broker in turn auctions the drugs on his catalogue, the order of precedence in which each broker mounts the rostrum is drawn for, and consequently varies from sale to sale. This is necessary, as buyers are likely to make sure of their requirements nearer the beginning of the sale than the end. The order of sale is

printed at the top of each catalogue (see Fig. 13). The actual sale has been described as follows :— *

" About 10.30 a.m. the first selling broker mounts the rostrum and commences to go through the lots in his catalogue, one for each broker, the number of which vary from twelve to fifteen,† and such is the celerity with which business is dispatched nowadays that the event is concluded by noon or shortly after. The wholesale druggists sit together on either side or under the rostrum, and the export merchants and dealers face the auctioneer in front, while the brokers are

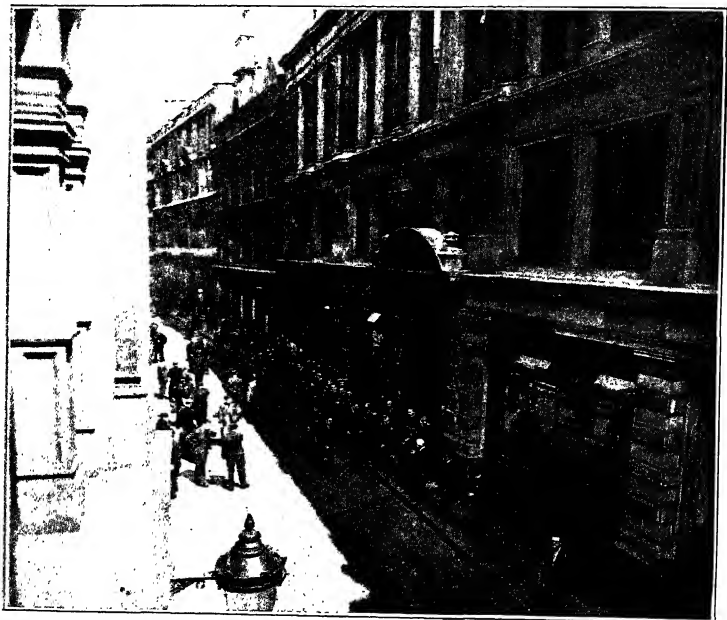


FIG. 17. — " On the kerb " outside the London Commercial Sale Rooms (*Chemist and Druggist*).

d at the sides or in front. Each lot is knocked down to the bidder or 'bought in.' The latter term signifies that the lot has not obtained a bid, or that the highest bid obtained is below the reserve price or the seller's limit, and the lot is not sold. The price at which the goods are bought in 'is in every case higher than that at which the goods are sold. Frequently an article is sold 'subject,' that is

* *C. and D.*, 1928, 1, 863.

† Now usually eight to twelve.—G. E. T.

to the owner's approval of the price which the broker accepts. This frequently happens when a principal has not given his broker a firm price below which he must not sell, and when the bid provisionally accepted is below the current market price or the broker's valuation. By far the larger proportion of the goods are 'bought in'; but in a number of instances the goods are immediately sold privately, and after his auction a broker will be found in the adjacent passages conferring with the buyer. Publicity in regard to his business is not sought after by a broker, and that is why the phrase 'See you afterwards' is a frequent utterance from the rostrum when a public bidder who wants the goods will not pay the price asked. This means that the buyer usually gets the goods at a secret price, so that not even his competitors are aware, let alone the trade Press."

Although London is by far the most important British port for the importation of drugs, considerable quantities also arrive at Liverpool. Large quantities of seeds, such as linseed and castor seed, arrive and are crushed for the extraction of their oil at Hull. In conclusion, students are advised to make a regular habit of reading the market reports which appear in the *Pharmaceutical Journal* and the *Chemist and Druggist*.

CHAPTER III

PLANT PRINCIPLES AND THEIR EXTRACTION

BY W. R. HEADING, B.Sc., Ph.C., A.I.C.

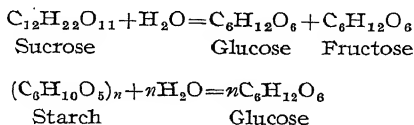
THE plant principles which are extracted for medicinal purposes may be broadly classified as follows : (1) carbohydrates, (2) glycosides, (3) alkaloids, (4) fixed oils, fats and waxes, (5) volatile oils, and (6) resins, gum-resins, etc. In the following pages the characters and typical methods of extraction of the above classes of substances will be briefly outlined.

CARBOHYDRATES

Carbohydrates are compounds containing the elements carbon, hydrogen, and oxygen, the last two elements being usually present in the proportions in which they are found in water. The group includes sugars, starch, inulin, and celluloses. The simple sugars of the formula $C_6H_{12}O_6$, which are known as *hexoses*, are represented in plants by glucose and fructose. Their synthesis in the plant may be represented in its simplest form by the equation :

Plants also contain *disaccharides* of the formula $C_{12}H_{22}O_{11}$, such as sucrose and maltose ; *trisaccharides* of the formula $C_{18}H_{32}O_{16}$, such as gentianose and mannotriose ; and *polysaccharides* of the formula $(C_6H_{10}O_5)_n$, such as starch, inulin, and cellulose. The above may be regarded as derived from two or more monosaccharide molecules by the elimination of water. Their structure may be studied by subjecting them to hydrolysis, either by enzymes or dilute acids, and identifying the sugars produced. Sugars are distinguished from one another by such properties as optical rotation, the microscopical form and melting-point of the crystals of their osazones, and their effect on Fehling's solution.

The hydrolysis of sucrose and starch may be represented :



For tests on carbohydrates such as starch, soluble starch, dextrin, and cellulose see Chapter IX.

Sucrose (Sacrosum, B.P.) is a disaccharide obtained from the sugar-cane (*Saccharum officinarum*) or the sugar-beet (*Beta vulgaris*). The sugar-cane is grown in the southern U.S.A., the West Indies, Queensland, the Philippines and India. About twelve months after planting, the canes are cut while still green and removed to the mills. About 14 tons of cane per acre, having a sugar-content of about 16 per cent., is considered a good yield. The green cane, stripped of leaves, is pressed between very heavy rollers, which rupture the cells and squeeze out the juice. Extraction may be assisted by spraying the canes with water. From 75 to 90 per cent. of the juice is removed and the exhausted cane or "bégasse" is usually used as fuel. The juice is next strained, boiled with lime to neutralise free organic acids which would otherwise cause hydrolysis or inversion of the sugar, and the scum which rises to the top is removed. The liquid is then filtered through a filter-press prior to concentration. At one time the evaporation of the solution over fires caused decomposition of the sugar, producing much caramel and yielding a brown, though very palatable, sugar. The concentration is now done at a much lower temperature (160°–180° F.) in multiple-effect evaporators heated by steam. When the sugar has crystallised, the crystals are centrifuged to separate them from the syrupy molasses. The solid mass which remains in the centrifuge is usually shipped to the consuming countries for refining there. Much sugar refining is done at Liverpool and Greenock, and at many of the beet factories when these are not fully engaged with their own crop. The refining process involves the use of charcoal as a decolourising agent.

Sugar-beet is widely grown in England and Europe. The method of extraction is called the "diffusion process." The beet is cut into slices or "cossettes" and extracted with water at 85°–95° F. The plant is arranged so that each "cossette"

passes from a liquid of high sugar-content to pure water, with the result that extraction is almost complete. The solution, on the other hand, as it becomes concentrated meets less and less exhausted samples of beet. The process has the further advantage that the walls of the beet cells act as filters, the gums and proteins being retained and a remarkably pure sugar is obtained. The final liquor contains about 18 per cent. of sugar. Lime is added to neutralise acids and coagulate water-soluble proteins and the liquid is treated with carbon dioxide. After filtration, to remove the precipitated calcium carbonate, etc., the liquid is evaporated under diminished pressure. The "factory white" sugar obtained by the first crystallisation of the concentrated liquor is usually put on the market without further refining.

The pharmacopœial tests for purity should be noted. The test for ultramarine is necessary as this substance is sometimes added as a "blueing" agent to disguise the brown colour of slightly impure sugar. A limit test for reducing sugars is given, since these might be produced as a result of accidental hydrolysis of sucrose by acids during extraction or purification. Limit tests for barium and strontium are provided, since the hydroxides of these metals are capable of forming additive compounds with sugar and this property is sometimes made use of to recover sugar from molasses. The "saccharate" is decomposed by treatment with carbon dioxide and the insoluble carbonate filtered from the sugar solution.

For the preparation of other carbohydrates, see starch soluble starch, dextrin, honey, and manna.

GLYCOSIDES

Glycosides are substances which on hydrolysis, brought about by enzymes or reagents, yield one or more sugars among the products of the reaction. The non-sugar part of the molecule is termed the *aglucone*. The name *glucoside* is strictly applicable only to those glycosides which yield glucose on hydrolysis. Similarly the term *pentoside* indicates a glycoside yielding a sugar such as arabinose, $C_5H_{10}O_5$; while *rhamnosides* yield rhamnose (a methyl pentose), $CH_3.C_5H_9O_5$, and *rhamnoglycosides* yield rhamnose and glucose. Although the name *glucoside* is frequently used to embrace all the above types, the name *glycoside* is preferable for this purpose. The following examples may be noted :—

Glycoside.	Formula.	Aglucone	Sugars produced on * Hydrolysis.
Salicin	$C_6H_{11}O_5 \cdot O \cdot C_6H_4 \cdot CH_2 \cdot OH$	$C_6H_4(OH) \cdot CH_2 \cdot OH$ Saligenin	$C_6H_{12}O_6$ d-Glucose
Barbaloin	$C_{20}H_{20}O_8$	$C_{15}H_{12}O_4$ Aloe-emodinanthranol	$C_5H_{10}O_5$ d-Arabinose
Quabain or g-strophanthin	$C_{29}H_{44}O_{12}$	$C_{23}H_{34}O_8$	$CH_2 \cdot C_3H_5O_5$ Rhamnose
Glucofrangulin	$C_{27}H_{30}O_{14}$	$C_{15}H_{10}O_5$ Emodin	$C_6H_{12}O_6 + C_6H_{12}O_5$ Glucose Rhamnose

The products of hydrolysis of many glycosides have yet to be determined and the following classification will be found useful.

Class.	Drugs in which they are found.
1. Anthraquinone glycosides	Rhubarb, Senna, Cascara, and Aloes.
2. Cardiac glycosides ..	Digitalis, Strophanthus, and Squill.
3. Saponins	Quillaia, Senega, and Sarsaparilla.
4. Glycosidal Colouring Matters	Senna, and Red rose petals.
5. Cyanogenetic Glycosides	Bitter almonds, Cherry-laurel leaves, and <i>Prunus serotina</i> bark.
6. Isothiocyanate Glycosides	Mustard seeds, and Horse-radish root.

Saponins froth when shaken with water, and in the dry state are sternutatory. When hydrolysed by boiling with dilute acids a sparingly soluble sapogenin is produced together with one or more sugars. Whereas the saponins are protoplasmic poisons and destroy red blood corpuscles when injected into the blood stream the sapogenins are usually non-poisonous. The glycosidal colouring matters are generally derivatives of flavone. Cyanogenetic glycosides, as their name implies, yield hydrocyanic acid as one of the products of their hydrolysis, while the isothiocyanate glucosides yield compounds such as allyl isothiocyanate, $C_3H_5 \cdot N : C : S$.

The simpler glycosides are commonly colourless, crystalline substances having a bitter taste. They are usually soluble in water or dilute alcohol forming laevorotatory solutions. Glycosides are usually associated in the plant with hydrolysing enzymes, a fact which is made use of in the making of medicinal preparations from drugs containing cyanogenetic and *isothiocyanate* glycosides. Similarly the action of an oxidase enzyme in vanilla pods is encouraged as it leads to the formation of vanillin. In many other cases enzyme action is to be avoided. In addition to the above relatively simple glycosides plants frequently contain complex glycosidal material such as gums, mucilages, tannins and glycosidal resins.

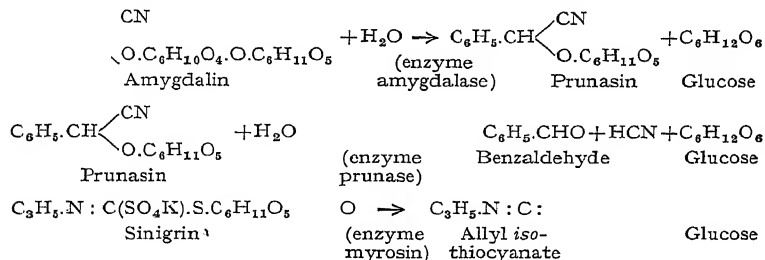
Glycosides are distinguished from one another by physical properties such as melting-point and optical rotation, and chemically by the investigation of their products of hydrolysis. Reducing sugars may be tested for by means of Fehling's solution. Saponins, on hydrolysis, usually give a precipitate of the sparingly soluble sapogenin, and cease to froth on shaking. Cyanogenetic glycosides yield a blue colour when tested with filter-paper which has been previously treated with an alcoholic solution of guaiacum resin and an aqueous solution of copper sulphate or a brick-red colour with sodium picrate paper (see p. 458). *Isothiocyanate* glycosides have a pungent taste and when heated with soda-lime yield hydrogen sulphide, which gives a dark stain to lead acetate paper. Other tests, such as the red colour given by salicin and the green colour given by *k*-strophanthin with sulphuric acid are useful in special cases.

Extraction.—No general method can be given for the extraction of glycosides, since the method adopted in each case must depend on the constituents of the drug other than the glycoside and on the relative stability of the active product. Some glycosides are readily hydrolysed while others, such as aloin, are extremely stable.

A. Hydrolysis not desired.—In many cases use is made of the solubility of the glycoside in water (*e.g.* salicin and commercial "saponin") or alcohol (*e.g.* convallamarin and arbutin). Other substances extracted from the plant, such as gums and tannin, are then precipitated by means of lead acetate, milk of lime, etc. The liquid is filtered and concentrated, when the glycoside frequently crystallises out. It may be purified by such means as redissolving and filtering through animal charcoal, recrystallisation, or by washing the crystals

with solvents which remove impurities but do not dissolve the glycoside. In other cases inert matter may be extracted before any attempt is made to obtain the glycoside, *e.g.* strophanthus seeds are defatted with ether or petroleum spirit prior to the extraction of strophanthin.

B. Hydrolysis required.—In the case of glycosides of the cyanogenetic and *isothiocyanate* classes hydrolysis is required to take place. The drug is ground, macerated with water for some hours, and the volatile products of hydrolysis distilled off. The following equations represent the hydrolysis of *amygdalin* (from bitter almonds) and *sinigrin* (from black mustard seeds or horseradish root). In the case of amygdalin the two sugars are removed in turn by different enzymes.



Examples of glycosides which are extracted on a commercial scale are aloin, salicin, tannin, quillaia saponins, strophanthins, and the glycosides of digitalis.

ALKALOIDS

The term alkaloid, although formerly used to denote all naturally occurring basic substances, is now usually restricted to relatively complex basic substances of plant origin possessing some physiological action. Alkaloids are cyclic nitrogenous bases derived from such compounds as pyridine (*e.g.* the hemlock alkaloids), tropine (the solanaceous alkaloids), quinoline (cinchona and nuxvomica alkaloids), *isoquinoline* (many of the alkaloids of the Papaveraceae), glyoxaline (jaborandi alkaloids), and purine (theobromine and caffeine).

Alkaloids are usually crystalline, but a few, such as nicotine, are liquid. The free bases are usually only slightly soluble in water, but the salts which they form with acids are, as a general rule, water-soluble. Generally speaking, the free bases are

soluble in organic solvents, and the salts but slightly soluble. These facts make the isolation and purification of alkaloids relatively simple, and, since the isolation of morphine by Sertürner in 1816, the number known to science has increased year by year.

Following the synthesis of coniine by Ladenburg in 1886 the structures of many, but by no means all, alkaloids have been elucidated. Although plants still form the primary source of most alkaloids, and are likely to continue to do so, the yield may frequently be increased by suitable chemical treatment. Examples of this are the "working up" of the coca alkaloids into cocaine (see p. 416), and of the ipecacuanha alkaloids into emetine (see p. 614.)

Tests.—Most alkaloids are precipitated from neutral or slightly acid solution by Mayer's reagent (potassio-mercuric iodide solution), solution of iodine, solution of tannic acid and saturated solution of picric acid. Alkaloids of the purine group (theobromine and caffeine) and colchicine are not precipitated by Mayer's reagent. Purine alkaloids may be identified by mixing them with potassium chlorate and hydrochloric acid, evaporating to dryness, and exposing the residue to the vapour of ammonia when a purple colour is produced (the murexide test). Special tests for other alkaloids will be found under individual drugs.

Extraction.—Alkaloids are usually present in plants in the form of salts of organic acids or associated with tannins. The cinchona alkaloids, for example, are associated with quinic acid and a phlobatannin, cinchotannic acid; the opium alkaloids with meconic and sulphuric acids; while the purine alkaloids are usually present in the fresh plant as unstable alkaloidal-phlobatannin glycosides. As the basic properties of alkaloids vary, hydrolysis of the salts takes place to a greater or lesser extent. In opium, for example, strong bases such as morphine and codeine remain combined with the acids, while weak ones such as narcotine are mainly present in the free state.

Widely differing methods of extraction are employed in different cases, but the first stage of the process usually consists of the liberation of the free bases. This may be done by moistening the drug with water and mixing it with an alkali such as lime or magnesia. The mixture is then extracted, in large percolators or an apparatus of the Soxhlet type, with an organic solvent such as alcohol or petroleum spirit. The organic

acids and tannins are rendered insoluble by the alkali used, while the free alkaloids dissolve. The percolate is concentrated, under diminished pressure if the alkaloid is liable to decomposition. When most of the solvent has been recovered, acidified water is added. This throws out resin from an alcoholic menstruum while keeping the alkaloid in solution in the form of a salt, or, if an immiscible solvent such as petroleum spirit is being used, the alkaloid passes into the aqueous liquid while the resin and other non-alkaloidal material remains in the organic solvent. In the latter case agitation is necessary to assist extraction.

If alkaloidal salts are required they may be obtained by concentrating the acid liquid until crystallisation takes place. More frequently, the alkaloids are precipitated by the addition of excess of sodium bicarbonate or ammonia, filtered off, washed and dried. In practice drugs are usually found to contain several alkaloids the separation of which is necessary. This is done by fractional precipitation, or by fractional crystallisation of such salts as the oxalates, tartrates, or picrates. The official assay of cinchona provides an example of the separation of alkaloids by means of their tartrates.

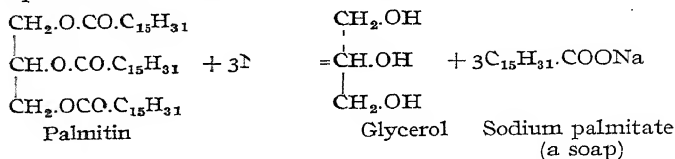
The Pharmacopœia ensures that allied alkaloids are removed from official substances by specific tests, *e.g.* for the absence of apoatropine in atropine; for *iso*atropylcocaine and cinnamylcocaine in cocaine; for "other alkaloids" in hyoscyamine and pilocarpine; and for "limit of brucine" in strychnine hydrochloride.

Volatile liquid alkaloids such as nicotine and coniine are usually prepared by distillation. An aqueous percolate is made alkaline with caustic soda or sodium carbonate, and the alkaloid distilled off in steam.

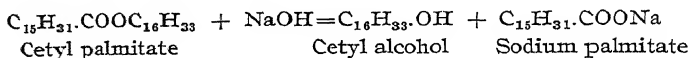
FIXED OILS, FATS, AND WAXES

Fixed oils, fats, and waxes are esters of aliphatic acids. The fatty acid series includes saturated acids such as lauric acid $C_{11}H_{23}.COOH$, myristic acid $C_{13}H_{27}.COOH$, palmitic acid $C_{15}H_{31}.COOH$, stearic acid $C_{17}H_{35}.COOH$, arachic acid $C_{19}H_{39}.COOH$, and melissic acid $C_{29}H_{59}.COOH$, and unsaturated acids such as oleic acid $C_{17}H_{33}.COOH$ and linolic acid $C_{17}H_{31}.COOH$. In fats and fixed oils the above acids are combined with the trihydric alcohol glycerol. On saponification with caustic soda solution a soap and glycerol are formed

according to an equation such as the following, which represents the saponification of glyceryl palmitate or palmitin :



Waxes are also esters of fatty acids, but in this case they are combined with the higher monohydric alcohols such as cetyl alcohol $\text{C}_{16}\text{H}_{33}\text{.OH}$, and melissyl alcohol $\text{C}_{30}\text{H}_{61}\text{.OH}$. The saponification of spermaceti, which consists chiefly of cetyl palmitate, may be represented :



Fixed oils, fats, and waxes may be either liquid or solid at ordinary temperatures and of vegetable or animal origin. For example, olive oil, cocoa butter, and carnauba wax are of vegetable origin, while in the animal kingdom a similar gradation of properties is shown by cod-liver oil, lard, and beeswax. The fluidity or otherwise of fats and fixed oils depends on temperature, molecular weight, and on whether the esters are derived from saturated or unsaturated acids. For example, liquids such as olive oil and cod-liver oil are rich in esters of unsaturated acids, while oil of theobroma and suet consist chiefly of esters of saturated acids.

The determination of the chemical constants of oils, fats, and waxes is described in the Pharmacopœia. The amount of unsaturated acids present is indicated by the iodine value. Drying and semi-drying oils such as linseed oil and cod-liver oil have high iodine values. Since every ester requires a definite percentage of sodium hydroxide for its saponification the saponification value of each oil only varies within narrow limits and an abnormal value points to adulteration. The same remark applies to the iodine value. The use of inferior plant or animal material, careless extraction or long storage may lead to partial hydrolysis of the esters present with the formation of glycerol and a free fatty acid. For example, if castor seeds are ground with water and allowed to stand for some time the liquid soon becomes acid to litmus, owing to the action of the lipase present in the seeds on the castor oil.

A determination of the amount of free fatty acids present in an oil or fat is therefore some indication of purity and freshness.

Vegetable Oils and Fats

Vegetable oils and fats occur mainly in the endosperm or embryo of the seed. Palm oil and olive oil are exceptional in this respect, since they are obtained from the fleshy pericarp of the fruit. The production of oils and fats in a form suitable for medicinal or dietetic use may be considered in the following stages :—

(i) **Initial Treatment.**—As the fruits or seeds are collected, decayed, immature, or over-ripe ones should be rejected or kept separate from those in good condition. On arrival at the factory it may be necessary to remove sand or other foreign matter from the material. This may be done by sieves of various degrees of fineness, by means of fans or by gravity separation. In the case of American cotton seed the hairs adhere very tenaciously to the testa and delinting machines must be used. Egyptian cotton seed, on the other hand, is usually fairly free from hairs and delinting is unnecessary. Cotton seed, linseed, and other small seeds are frequently found to contain pieces of iron. As this would be very harmful to the machinery subsequently used, the seeds are passed over an electro-magnetic separator. One of these, which is capable of dealing with from 20 to 60 tons of seed per hour, is shown in Fig. 18.

(ii) **Decortication.**—In the case of many oily seeds, notably castor seed and coconut ("copra"), and fruits such as the earth nut (*Arachis hypogæa*), it is necessary to remove the testa or pericarp, which contains no oil. This is done by passing the material between rollers with sharp cutting edges or grooves which break the testa or pericarp without injuring the oil-containing "kernels." Material passing uncracked through the first set of rollers may be passed through a second "huller" * in which the rollers are set more closely. Shaking

* For the benefit of those wishing to read technical works on the production of oils and fats it will be useful to mention a few terms applied to the materials, which do not clearly indicate their botanical nature. The terms "seed" and "nut" are applied to a fruit or to the seed which still possesses its testa. The pericarp or testa is the "shell," "cortex," "husk," or "hull," and is cracked to separate the oil-containing "kernel" or "meat." The oily mesocarp of palm and olive fruits is termed the "pulp." Machinery is often named after the particular part of the plant with which it has to deal as in the case of the "huller" mentioned above.

The oil machinery illustrated in this chapter is made in Nottingham by

screens are attached to the machines to sift the broken hulls and untouched fruits from the kernels. In the case of the decorticating machine shown in Fig. 19, which is used for castor seeds, "the shell and kernel drop from the rolls on to a shaking separator which separates the kernel from the husk, and both husk and kernel pass through a blast of air, which

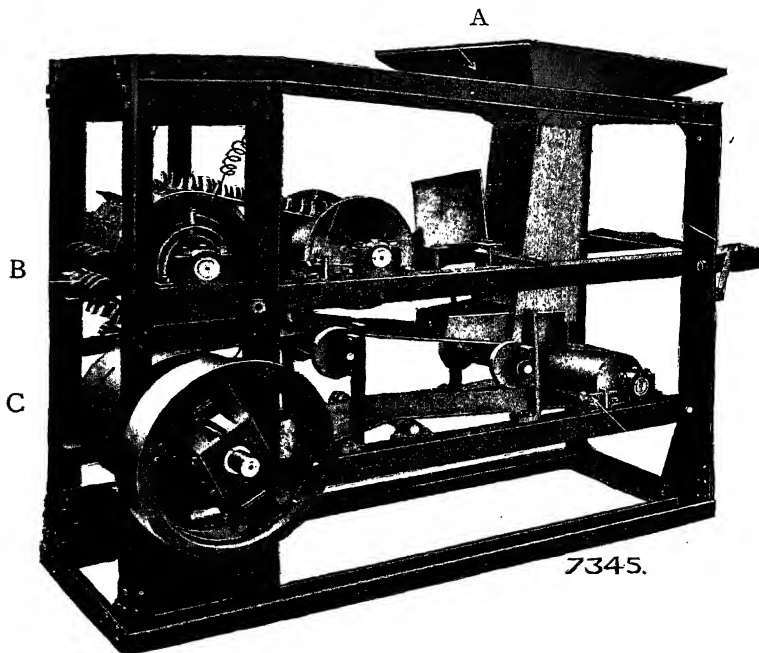


FIG. 18.—Electro-Magnetic Separator. A, feed hopper; B, "feelers," which become magnetised as they approach the magnetic drum and "feel" for iron in the seed. This they carry until, after passing the drum, they become demagnetised and the iron is thrown off; C, the belt carrying the seed. (Manlove, Alliott & Co., Ltd., Nottingham.)

is delivered by a blower through the delivery spout of such a strength as to divert the husk whilst permitting the kernel to flow in the right direction." In the case of palm and olive

Messrs. Manlove, Alliott & Co., Ltd. A valuable article by Mr. B. P. Flockton, M.I.Mech.E., a member of the above firm, appeared in the *Machinery Market* of June, 1922, under the title of "The Production and Refining of Vegetable Oils."

oils, where the pericarp contains the oil, somewhat different methods apply. The palm yields two oils, "pulp oil" or "palm oil," obtained from the pericarp, and "palm kernel oil," from the seed. The former is first prepared by the "centrifuging process," described below. The "nut" which remains is then shelled and palm kernel oil obtained from it by hot expression. Olives are often ground whole in edge-runner mills and then subjected to cold expression.

(iii) **Milling.**—The oil-containing kernel or, in such cases as linseed the whole seed, is next carried by gravity or belt

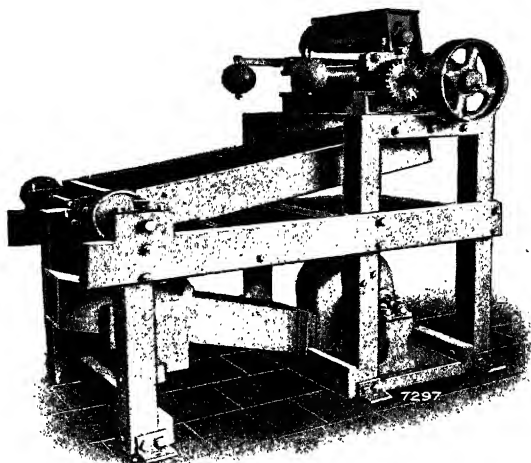
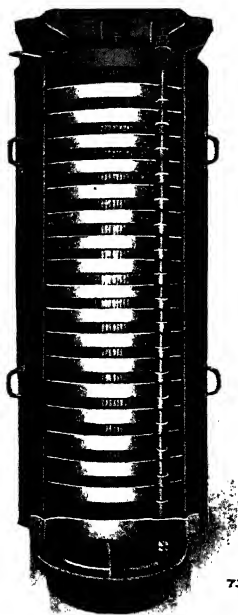


FIG. 19.—Castor Seed Decorticator. (Manlove, Alliott & Co., Ltd., Nottingham.)

conveyers to a further set of rollers, which are designed to cut up rather than to crush the seeds. The degree of fineness required varies with the nature of the material and with the process of extraction to be afterwards used. If a fine powder is required this is obtained by passing the meal through a set of "finishing" rollers or it is ground in mills. For the "hot-expression" process too fine a meal is not required.

(iv) **Extraction** may be effected by pressing the meal, with or without previous heating, by means of solvents, or, in the case of pulpy fruits, by means of centrifuges.

(a) Pressure is used for extracting most of the oils used in medicine, since it gives a product little contaminated with non-fatty material. For medicinal oils, like "cold-drawn" castor oil, the milling stage is often omitted and the kernels delivered into a "cage press," where 6-inch layers of kernels are separated by means of steel plates until the hydraulic press is full. The press is made of vertically arranged steel



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FIG. 20.—Cage Press. (Man-
love, Allott & Co., Ltd.,
Nottingham.)

bars set about $\frac{1}{100}$ inch apart (Fig. 20). In this particular case a pressure of 35 cwt. per sq. inch is applied to give the finest oil, which escapes between the bars and is collected. The residual cake is then broken between rollers, heated and moistened with steam in a "heating kettle," and again pressed in a cage press. In the second pressing about 3 tons pressure per sq. inch is used. Another type of press, which is often used when the material is in the form of meal, is made of horizontal plates between which the meal is placed in press-bagging. The machines shown in the foreground of Fig. 21 are for moulding the meal into the press-bagging and for paring the press cake into a regular shape for cattle feeding. Behind these will be seen an Anglo-American press of the type just described, a heating kettle, and a set of Anglo-American rolls. Hot expression allows of more complete extraction than cold expression, and for relatively cheap oils,

such as cotton-seed oil and linseed oil, which are used for technical purposes, a cold expression is omitted. The coarse meal is delivered to a steam-heated kettle fitted with agitating gear in which it is heated to about 170° F. and about 15 per cent. of moisture added. The hot meal is then filled into press-bagging by means of the hydraulic moulding machines and

placed in the press, where it is usually subjected to a pressure of about 1,500 lb. per sq. inch. In the case of cotton seed the cake then contains about 4.5 to 5 per cent. of oil. By adjusting the pressure used the amount of residual oil can be arranged to meet the requirements of the cattle cake market.

(b) **Solvent extraction** is suitable for technical oils and gives almost complete extraction of the material. It may be used to extract the whole oil-content of the seed or may be applied to the press cake remaining after the expression process. The material is coarsely milled and a solvent, such as "benzine" or trichlorethylene ("westrosol"), passes through

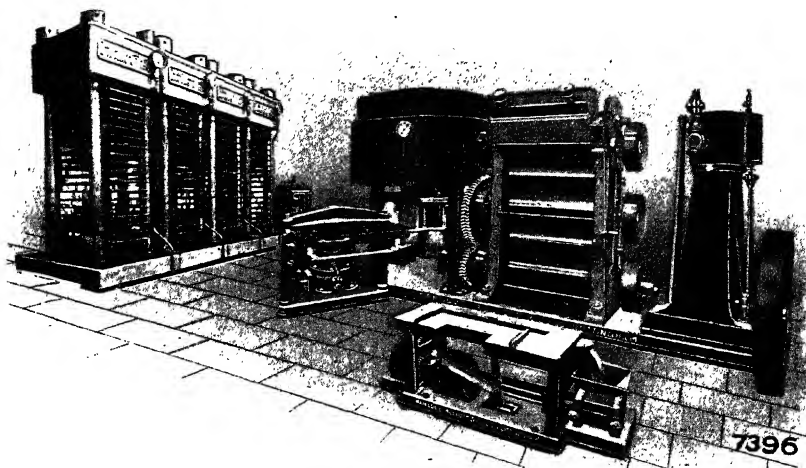


FIG. 21.—A Self-contained Anglo-American Oil Mill. (Manlove, Alliott & Co., Ltd., Nottingham.)

it in a series of large vessels at a temperature a little below the boiling-point of the liquid. The solution of the oil is passed into a still in which most of the solvent is recovered. From this "stripping-still" the oil is passed down a fractionating column against a current of steam which carries off almost every trace of the solvent. The oil is allowed to settle and is strained from any deposit.

(c) **The Centrifuging Process.**—This method, suitable for a relatively pulpy material, has been successfully applied to the production of palm oil. The whole fruits are heated in steaming ovens, then in macerating machines, where they are

sprayed with steam, and finally, to a very high temperature, in steam-heated vessels. From the latter the oily mass is run into a centrifuge which is revolved at a high speed until the extractor contains an almost dry mass of fibre and nuts, all the oil being thrown into an outer jacket. As previously mentioned, the kernels contain a second oil, which is now obtained by drying the nuts, cracking them and extracting the kernels.

(v) **Refining** consists of chemical treatment designed to produce a clear odourless oil, free from rancidity. Cold-drawn oils usually require no treatment other than filtration. After determining the free fatty acid in the crude oil, the theoretical amount of aqueous sodium hydroxide is added to the oil in a neutralising vessel fitted with agitating gear. The oil is heated and the fatty acids react with the alkali to form soap which, when stirring is stopped, sinks to the bottom. The oil is drawn off and passed through a filter press. Edible oils undergo subsequent washing with water and decolourisation with fuller's earth or kieselguhr, and are finally deodorised. The latter process consists of the removal of "volatile acids" by means of superheated steam. The refined oil, now dried and almost odourless, is allowed to cool before being exposed to the air (as atmospheric oxidation takes place more rapidly with a hot oil), and filled into suitable containers.

Cotton-seed oil is often refined, and it will be noted that the Pharmacopœia requires it to be free from alkali.

Animal Oils and Fats

Animal oils and fats may be extracted by expression or by means of solvents, but the process of "rendering" is the most usual one. The minced animal tissues are treated with hot water or steam in lead-lined tanks, or by steam under pressure in "digestors." The oil or fat separates out and may be drawn off and cooled. For details of rendering, refining, and hydrogenating animal fats reference should be made to larger works. The extraction of cod-liver oil is described on p. 656.

Animal and Vegetable Waxes

The fact that waxes are obtained from such widely different sources makes it impossible to indicate a method of extraction which will apply to all cases. A few examples will therefore be given. Carnauba wax, an important article of commerce, occurs on the leaves of the Brazilian wax palm, *Copernicia cerifera*, from which it is scraped, clarified in boiling

water, refined, and bleached. Beeswax is obtained from the honeycomb by melting under water and straining. From the yellow beeswax so obtained the white beeswax may be prepared by bleaching (see p. 649). Spermaceti is prepared from the crude sperm oil drawn from a cavity in the head of the sperm whale. As the crude oil cools the spermaceti separates out. It is purified by melting, washing with dilute alkali, and finally with pure water.

VOLATILE OILS

Volatile or essential oils are usually mixtures of the terpenes and their derivatives. Exceptions to the above rule are oil of mustard, oil of wintergreen, volatile oil of almonds, and oil of chamomile. Under the name terpene one usually includes the true terpenes of the formula $C_{10}H_{16}$, the sesquiterpenes, $C_{15}H_{24}$, and the diterpenes, $C_{20}H_{32}$. From these three types of hydrocarbons are derived the numerous alcohols, phenols, ketones, aldehydes, and esters which are found in volatile oils. As their name implies, these oils are volatile in steam. They thus differ markedly in both chemical and physical properties from the fixed oils.

With the exception of oils such as oil of bitter almonds, which are produced by the hydrolysis of glycosides, volatile oils are contained as such in the plant. They are secreted in oil cells or in secretion ducts and cavities, where they are frequently associated with other substances such as gums and resins. Volatile oils are used for their medicinal action (*e.g.* oil of eucalyptus), for flavouring (*e.g.* oil of lemon), or in perfumery (*e.g.* oil of rose). In pharmacy, however, oils are used for all three purposes. The various methods of extraction may be indicated under the following headings:

Extraction of Official Oils.—All the official volatile oils are extracted by distillation, with the exception of oil of lemon (see p. 432) and oil of cade (see p. 218).

The distillation of volatile oils by means of water or steam has long been practised, but modern plant for the purpose possesses many advantages over the older stills, in which charring and undesirable decomposition of the oil often took place. From the principles of steam distillation* it will be evident that oils with a boiling-point considerably over 100° will pass over with steam. Modern volatile oil stills contain

* See Bentley's *Text Book of Pharmaceutics*, p. 202, and Figs. 73 and 74.

the raw material on perforated trays or in perforated baskets. The still contains water at the base which is heated by steam coils, and free steam under pressure may also be passed in. Tough material such as barks, seeds, and roots may be comminuted to facilitate extraction, but flowers are usually placed in the still without further treatment as soon as possible after collection.

The distillate, which consists of a mixture of oil and water, is condensed and collected in a suitable receiver. The latter is usually a Florentine flask or a large glass jar with one outlet near the base and another near the top. The distillate separates into two layers, the oil being withdrawn through the upper outlet and the water from the lower outlet, or vice versa in the case of oils such as oil of cloves which are heavier than water. The aqueous layer, which is saturated with oil, may be returned to the still or may form an article of commerce, as in the cases of rose water and orange-flower water.

Certain official oils, *e.g.* oil of cajuput, oil of caraway, oil of turpentine, and oil of Australian sandalwood, are rectified. Rectification usually takes the form of a second distillation in steam, which frees the oil from resinous and other impurities. The effect of rectification is seen if a sample of bluish B.P. 1914 oil of cajuput is compared with that now official, or if official oil of turpentine is compared with the unrectified product. Light and atmospheric oxygen appear to have an adverse effect on most volatile oils and the official directions with regard to storage should be rigidly followed. The distillation of oil of chenopodium must be done as rapidly as possible, as the chief constituent, ascaridole, gradually decomposes on boiling with water.

Extraction of Oils Used in Perfumery.—Certain oils used in perfumery, such as oil of rose, are prepared by steam distillation as described above, but many of the flower perfumes require other treatment. The most important centre for the extraction of flower oils is Grasse, in the south of France. Here the oils are extracted by *enfleurage*, by digestion in melted fats, by pneumatic methods, or by means of solvents. In the *enfleurage* process glass plates are covered with a thin layer of fixed oil or fat upon which the fresh flowers are spread. The volatile oil gradually passes into the fat and the exhausted flowers are removed and replaced by a fresh supply. Formerly the flowers had to be picked off by hand, but this is now done mechanically. Only a small percentage of the flowers, which

resist the action of the machine, require removal by the fingers or by means of a vacuum cleaner. The pneumatic method, which is similar in principle to the *enfleurage* process, involves the passage of a current of warm air through the flowers. The air, laden with suspended volatile oil, is then passed through a spray of melted fat in which the volatile oil is absorbed. In the digestion process the flowers are gently heated in melted fat until exhausted, when they are strained out and the perfume-containing fat allowed to cool. It will be seen that in each of the above processes the volatile oil has now been obtained in a fatty base. The volatile oil is obtained from this by three successive extractions with alcohol. The alcoholic solutions may be put on the market as flower perfumes or the oil obtained in a pure form by recovery of the alcohol. Extraction by means of solvents is based on the Soxhlet principle.*

RESINS, GUM-RESINS, AND SIMILAR SUBSTANCES

The term "resin" is applied to more or less solid, amorphous products of complex chemical nature. On heating they soften and finally melt. They are insoluble in water, and usually insoluble in petroleum spirit, but dissolve more or less completely in alcohol, chloroform, and ether. Chemically, resins are complex mixtures of resin acids, resin alcohols (resinols) resin phenols (resino-tannols), esters, and chemically inert compounds known as resenes. Resinotannols differ from resinols in that they give a tannin-like reaction with ferric chloride.

Resins, as described above, are often associated with volatile oils (oleo-resins), or with gums (gum-resins), or with oil and gum (oleo-gum-resins). No hard and fast distinction can, however, be made between these groups, since products such as mastich and ammoniacum, which are usually considered as a resin and a gum-resin respectively, both contain volatile oil. Resins may also be combined in a glycosidal manner with sugars, as in the resins of the *Convolvulaceæ*.

The term "balsam" is often wrongly applied to oleo-resins such as Canada turpentine and copaiba, but should be reserved for such substances as balsam of Peru, balsam of Tolu, and storax, which contain a high proportion of aromatic balsamic acids. These balsams are partially soluble in water,

* For details see W. A. Poucher's *Perfumes, Cosmetics, and Soaps*.

owing to the solubility of benzoic and cinnamic acids, whilst resins are insoluble. Benzoin is perhaps best described as a balsamic resin.

The above products are usually contained in schizogenous or schizolysigenous ducts or cavities. They are often pre-formed in the plant (*i.e.* they are normal physiological products), but the yield is usually increased by injury, *e.g.* in the case of *Pinus*. Many products, *e.g.* benzoin and balsam of Tolu, are not formed by the plant until it has been injured : that is, they are of pathological origin. In passing it may be mentioned that some gums, *e.g.* tragacanth, are physiological products, whilst others, *e.g.* acacia, are of pathological origin. The gums which are often associated with resins and volatile oils usually resemble acacia gum in chemical nature and in the fact that they are often accompanied by oxydase enzymes. While resins are usually produced in ducts or cavities, they may be found in other positions, *e.g.* in the resin cells of bloodroot, in the elements of the heartwood of guaiacum, the external glands of Indian hemp, the internal glands of male fern, or the glands on the surface of the lac insect.

No general method can be given for the preparation of these substances, but students should refer to the preparation mentioned elsewhere of resins (colophony, dragon's blood, guaiacum, and shellac), oleo-resins (copaiba and crude turpentine), gum-resins and oleo-gum-resins (myrrh, asafetida, and gamboge), and balsams (storax, balsam of Peru, balsam of Tolu, and benzoin). In each case note should be taken of the origin of the drug in the plant system.

Among the products not yet mentioned in this chapter reference may be made to euphorbium and guttapercha, which are produced in latex cells, and opium, which is formed in latex vessels. Certain types of secretory organ occur with some regularity in particular plant families and genera, and such structures are therefore of considerable diagnostic importance, *e.g.* the vittæ of the Umbelliferae and the latex vessels of a portion of the Compositæ.

CHAPTER IV

ENZYMES IN VEGETABLE DRUGS *

ENZYMES are organic catalysts produced by living cells. A more precise definition is difficult to give since their chemical constitution is at present unknown. Enzymes are concerned in most of the metabolic processes of the plant such as the synthesis and hydrolysis of polysaccharides, glycosides, proteins, fats, and fixed oils. The enzymes bringing about these changes in the above groups of compounds are known as polyases, glycosidases, proteases, and lipases respectively. Many of the changes produced by enzymes in the plant only take place in the laboratory with considerable difficulty and under quite different conditions from those found in living matter. As Bechhold states :—

“ To split complex molecules, chemists have to employ powerful reagents, such as acids, alkalies, etc. They smash, as it were, the clock-work and then pick out the undamaged particles. Just as a watchmaker employs for each screw a suitable tool or a specially made pliers, so nature has constructed delicate instruments for this purpose. Enzymes are such tools for the chemical breaking down or building up of molecules.”

An enzyme usually acts on one substance or class of substances since it is specific for a particular atomic group or linkage. If the compounds containing that linkage are relatively few the enzyme will be regarded as highly specific and vice versa.

The amount of material which an enzyme will convert is many thousand times its own weight, and the gradual diminution in activity which takes place is probably due to secondary reactions which bring about destruction of the enzyme.

Like other catalysts enzymes influence the rate of a reaction without changing the point of equilibrium. For example, lipase catalyses either the synthesis of glycerides from glycerol and fatty acids or the hydrolysis of glycerides, the final point of equilibrium being the same in either case. Similarly β -glucosidase (prunase) has been used both for the synthesis and hydrolysis of β -glucosides. In plants such reversible reactions may proceed in one direction or the other

* Enzymes of animal origin are dealt with in *A Textbook of Physiology for Pharmaceutical Students* by H. H. Barber, B.Sc., Ph.D., F.I.C., a companion volume to this book. The present chapter is therefore confined to enzymes of vegetable origin.

under different conditions. In digitalis, for example, it has been shown that the amount of glycosides present in the leaf varies at different times of the day and under different conditions of illumination, whilst in Virginian prune bark and willow barks there is considerable seasonal variation in the amount of glycosides.

Enzymes are colloidal and non-diffusible and may be partly purified by fractional precipitation, dialysis, etc. It is extremely difficult, however, to free enzymes completely from the carbohydrate and protein material with which they are associated. Enzymes appear to become less "stable" when attempts are made to free them from these substances, the presence of which in small amounts is usually of little practical importance.

A crude enzyme-containing preparation which is widely used for the hydrolysis of β -glucosides is almond emulsin. This is a mixture containing at least three enzymes, namely, β -glucosidase (prunase) which acts on many β -glucosides (*e.g.* prunasin, salicin, etc.) and amygdalase and oxynitrilase which are specific for amygdalin and mandelonitrile respectively (see p. 457). A solution of emulsin may be prepared by infusing some coarsely powdered sweet almonds in cold water. To the strained solution add a little acetic acid, which precipitates some of the proteins, and filter. The addition of an equal volume of alcohol then causes the precipitation of emulsin which may be collected on a filter, washed with alcohol, and dissolved in water. This solution may be used for experiments on the hydrolysis of glucosides, and on the effect of the acidity or alkalinity of the medium and heat on enzymic activity.

The activity of enzymes is markedly affected by the reaction of the medium and the presence of substances such as salts. It is well known, for example, that pepsin works best in an acid medium and trypsin in an alkaline one. In general carbohydrases have pH optima of 3.8 to 7.5, lipases optima of pH 5 to 8, whilst enzymes which act on bases all have optima more alkaline than pH 7.

The effect of heat on enzymes is of considerable importance in the drying of drugs. At low temperatures enzymic changes are not usually marked although the proteolytic or protein-splitting enzymes in cod livers do bring about some hydrolysis at temperatures approaching zero (see p. 657). The optimum working temperatures of different enzymes vary, but they usually lie between about 35° and 50° . At temperatures about 60° destruction of the enzymes is usually fairly rapid although considerable loss may take place below this temperature.

The term "optimum working temperature" has no precise significance, for although increased temperature usually accelerates enzymic activity the increase may be more than compensated for by the destruction of the enzyme. The time required to attain equilibrium depends, of course, not only on the temperature but on the relative amounts of enzyme and substrate employed. In the drying of drugs the heat causes changes in the cell sap and loss of water both of which may influence enzyme action. In the interval between the collection and drying of a drug changes may take place which are desirable, *e.g.* gentian, or undesirable, *e.g.* belladonna. When dry enzymes show increased resistance to heat, thus zymase, which in the presence of moisture is rapidly inactivated at 50°, will when dry resist a temperature of 85°.

Enzymes are classified according to the reactions which they catalyse, the name of the enzyme being formed by adding the suffix "-ase" to the name of the substrate on which it acts. Thus inulase acts on inulin, gentiobiase on gentiobiose, and so on. Classes of enzymes may be named similarly, the term "esterase," for example, including lipases which hydrolyse fats, chlorophyllase which hydrolyses chlorophyll, etc. Many names such as pepsin, prunase (β -glucosidase), diastase (amylase), which were well established before the introduction of the present system of nomenclature, are still employed, as also are the names of enzymic mixtures such as emulsin and zymase.

Enzymes Hydrolysing Esters (Esterases).—To this group belong the lipases, which act upon an enormous number of compounds. All lipases, whether of animal origin or vegetable origin, *e.g.* castor seed lipase, hydrolyse glycerides. Mammalian lipases also hydrolyse such different esters as phenyl salicylate, acetyl choline, and atropine. Other esterases are chlorophyllase and tannase. Esterases probably occur in many drugs which contain volatile esters, *e.g.* valerian.

Enzymes Hydrolysing Sugars.—To this group belong sucrase (invertase), lactase, maltase, and gentiobiase, which hydrolyse sucrose, lactose, maltose, and gentiobiose respectively.

Enzymes Hydrolysing Polysaccharides.—Such enzymes, which are termed polyases, include the amylases (diastases) which hydrolyse starches, the cellulases which hydrolyse celluloses, hemicellulase, mannanase (seminase), and inulase.

Enzymes Hydrolysing Glycosides.—As previously mentioned β -glucosidase (prunase) hydrolyses β -glucosides. The corre-

sponding α -glucosides, which do not appear to be common in nature although they can be prepared in the laboratory, are hydrolysed by α -glucosidase (maltase). It may be pointed out that the disaccharide maltose, which is also hydrolysed by this enzyme, yields two molecules of glucose on hydrolysis and may be regarded as α -glucose glucoside. More specific glycoside-splitting enzymes are salicase, amygdalase, sinigrinase (myrosin), and digipurpidase which act on salicin, amygdalin, sinigrin, and desacetyldigilanic acid respectively. Glycoside-splitting enzymes produce important changes in vanilla pods, gentian, and cascara.

Enzymes Hydrolysing the C-N Linkage.—This class is represented in the animal kingdom by pepsin, trypsin, and erepsin. In the vegetable kingdom we find papain, asparaginase, urease, etc. Papain, which is present in the unripe fruit of *Carica Papaya*, hydrolyses proteins either in acid or alkaline media. Asparaginase, which is present in yeast, is a deaminating enzyme acting on substances such as asparagine (see althæa, p. 399, and liquorice, p. 474). Urease, which is present in soya beans, converts urea into ammonia and carbon dioxide, and is used in the determination of urea in body fluids.

Oxidases and Reductases.—Since any oxidation implies a simultaneous reduction the names oxidase and reductase may be applied to a single type of enzyme. A large number of so-called oxidases are not true enzymes since they are heat-stable. The following groups may be noted :—

1. *Oxygenases.*—These are organic or inorganic thermolabile complexes which take up oxygen with the formation of peroxides.

2. *Peroxidase.*—These are substances which increase the oxidising power of the peroxides mentioned above. The name is applied both to thermolabile and thermostable substances. The so-called oxidases are usually mixtures of 1 and 2, which form peroxide-peroxidase systems.

3. *Catalases* are enzymes which catalyse the decomposition of hydrogen peroxide to oxygen and water.

Oxidases are present in fresh digitalis leaves and horse-radish root and in acacia. If a drug contains a peroxide-peroxidase system it causes fairly rapid blueing of tincture of guaiacum alone. This is easily shown on a slice of potato. If a blue colour does not rapidly appear with guaiacum alone but does so in the presence of hydrogen peroxide, then only a peroxidase is present. Moist opium is said to contain a peroxidase called opiapase.

CHAPTER V

THE CULTIVATION OF MEDICINAL PLANTS

BY H. M. HIRST, M.P.S., F.R.H.S., AND G. E. TREASE

CERTAIN drugs are now obtained almost exclusively from cultivated plants. These include cardamoms, Indian hemp, ginger, Ceylon cinnamon, linseed, fennel, cinchona, and opium. In other cases both wild and cultivated plants are used. Some plants have been cultivated from time immemorial, *e.g.* flax, opium, poppy, and coca. Others are now grown because supplies of the wild plants are insufficient to meet the demand or because, owing to sparse distribution or inaccessibility, collection is difficult. Cultivation is essential in the case of drugs such as Indian hemp and opium which are subject to government control, and in many cases it is advisable because of the improved quality of the drug which it is possible to produce. The improvement may be due :—

(a) To the power to confine collection to species, varieties, or hybrids which have the desired characters, *e.g.* aconite, cinnamon, fennel, cinchona, and valerian.

(b) To the better development of the plants owing to improved conditions of the soil, pruning, and the control of insect pests, fungi, etc.

(c) To the better facilities for treatment after collection. For example, drying at a correct temperature in the cases of digitalis, colchicum, belladonna, and valerian, and the peeling of cinnamon and ginger.

A commercial grower of medicinal plants needs :—

(1) Land which is reasonably cheap and suited to the plants which it is desired to grow.

(2) Available labour when required.

(3) An assured market and suitable transport facilities. Preferably the farm should be situated near a pharmaceutical laboratory where galenicals can be manufactured, particularly at times when the crop is abundant and the market well supplied with crude drug.

(4) A practical experience of horticulture and agriculture.

This will include a knowledge of soils, manures, methods of propagation, means of defence against fungi, insects, and other pests, and in addition a knowledge of the methods of collecting, drying, and packing the drugs.

(5) Sufficient capital to meet all expenses for the first few years and provide facilities for drying, distilling volatile oils, etc.

For success in cultivation it is necessary to study the conditions under which the plant flourishes in the wild state and reproduce these conditions or improve on them.

Climate.—Plant growth is effected by temperature, rainfall, aspect, and altitude. In general the highest temperatures are experienced near the Equator, but as the temperature falls about 1° for every 343 feet of elevation, it is possible in, say, Jamaica to have a tropical climate on the coast and a temperate one in the mountains. The annual variations in temperature are just as important as the temperature of the hottest month. At Singapore the annual range of temperature is as little as 2.5° F., whereas Moscow, with its hot summer and cold winter, has a range of 52.7° F.

Plants vary much both in the amount and intensity of the light which they require. In the wild state the plant will be found where its shade requirements are met, and under cultivation similar shade must be provided. In certain cases research has shown that light is a factor which helps to determine the amount of glycosides or alkaloids produced. A northern and an eastern aspect are usually colder and moister than southern or westerly ones, but this is often modified by the lie of the land. In tropical climates wind protection is often necessary and is afforded by planting shelter belts of plants such as *Ricinus communis*.

Altitude must also be considered. The coconut palm needs a maritime climate, and the sugar cane is a lowland plant. On the other hand, tea (3,000–6,000 feet), cacao (300–500 feet), coffee (2,500–5,000 feet), medicinal rhubarb, tragacanth, and cinchona require elevation. In the case of *Cinchona succirubra* the plants grow well at low levels but produce practically no alkaloids.

Rainfall has a great influence on vegetation. Not only must the total rainfall be considered but whether it is evenly distributed throughout the year or whether it occurs only at certain periods. Thus in the cultivation of cacti, etc., in greenhouses some approach to natural rainfall conditions should be aimed at.

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A study of the following table will give some idea of the climatic conditions in different parts of the world :—

TEMPERATURE AND RAINFALL STATISTICS

	Mean Temp. of Hottest Month	Hottest Months	Annual Range of Temp.	Annual Rainfall	Wettest Months
<i>North America.</i>				inches	
Winnipeg ..	78° F.	June–Aug.	68·3° F.	20·4	May–Aug.
New York ..	82° F.	June–Aug.	43·5° F.	42·8	Uniform.
New Orleans..	90° F.	June–Aug.	27·5° F.	57·5	Uniform.
<i>West Indies.</i>					
Kingston ..	90° F.	Uniform.	5·0° F.	31·5	All wet, especially Aug.–Nov.
<i>South America.</i>					
Lima ..	84° F.	Uniform.	12·5° F.	2·1	Aug. and Sept.
Asuncion ..	94° F.	Dec.–Feb.	20·5° F.	51·8	Oct.–May.
Bahia ..	92° F.	Uniform.	6·0° F.	76·5	All wet, especially May–July.
<i>Europe.</i>					
London ..	72° F.	June–Aug.	20·6° F.	24·5	Uniform.
Bordeaux ..	80° F.	July–Sept.	25·1° F.	33·4	Uniform.
Moscow ..	77° F.	July–Sept.	52·7° F.	21·0	All wet, especially June–Sept.
<i>Africa.</i>					
Alexandria ..	88° F.	July–Sept.	22·6° F.	8·0	Nov.–Feb.
Timbuktu ..	112° F.	March–Oct.	24·2° F.	8·6	July and Aug.
Nairobi ..	78° F.	Uniform.	6·4° F.	40·1	Feb.–June and Oct.–Dec.
Cape Town ..	80° F.	Dec.–March.	15·5° F.	25·0	May–Sept.
<i>Asia.</i>					
Baghdad ..	110° F.	June–Sept.	46·0° F.	6·6	Nov.–April.
Delhi ..	100° F.	May–Aug.	36·1° F.	28·2	July–Sept.
Mangalore ..	92° F.	Uniform.	6·3° F.	125·7	June–Aug.
Singapore ..	88° F.	Uniform.	2·5° F.	95·0	All wet, especially Nov.–Jan.
<i>Australasia.</i>					
Darwin ..	96° F.	Uniform.	8·5° F.	61·9	Nov.–March.
Alice Springs	98° F.	Nov.–March.	35·7° F.	11·1	Jan.–March.
Brisbane ..	85° F.	Dec.–March.	19·0° F.	45·3	All wet, especially Dec.–March.
Christchurch..	70° F.	Dec.–March.	18·9° F.	25·2	Uniform.

Climatic Types of Vegetation.—The chief types of vegetation are *woodland*, *grassland*, and *desert*. Woodland is known as *forest* when the trees are close together, *bushwood* if shrubs are sufficiently abundant to keep the crowns of the trees from

touching, and *shrubwood* when shrubs are the chief feature. According to moisture supply grassland is divided into *meadow* and *steppe*. Xerophilous grassland with isolated trees is called *savannah*.

A. Tropical Woodlands.—*Tropical Rain-Forests*, such as are found in parts of Brazil, Southern Nigeria, Burma, and Malaya, only occur when the rainfall exceeds 40 inches. Their flora consists of evergreen trees at least 30 feet high, large lianes, and woody epiphytes. *Monsoon-forests* occur on the Malabar Coast and in Western Ceylon, Bengal, and Indo-China. In these the trees are typically smaller than those in a rain-forest and more or less leafless during the dry season. *Savannah-forest* is found in Minas Geraes (Brazil). The trees are usually less than 20 feet in height and often leafless in the dry season; there is little underwood but terrestrial herbs, especially grasses, are numerous. *Thorn-forests* are found in Mexico and Bahia (Brazil). They resemble savannah-forests in height and leaf-fall, but thorn-plants, underwood, and slender lianes are abundant, while terrestrial herbs are few.

B. Tropical Grasslands of the savannah and steppe types are found in Africa, South America, etc., where there are definite dry and wet seasons. The grasses may attain 6 feet in height and are often intermingled with herbaceous perennials, undershrubs, and isolated trees.

C. Temperate Woodlands.—In temperate climates there are fewer arborescent genera than in the tropics, but shrubs and herbs are well represented. Where the winters are mild the trees are evergreen or green during the rainy period, and have only a partial winter rest, but where the winters are cold (mean temperature of the coldest month about 6°) many trees are dormant and leafless. Conifers are particularly abundant on sandy or swampy soil and on mountains. Mild temperate districts with winter rain, *e.g.* the Mediterranean, South Australia, and California, possess evergreen, xerophytic trees such as the olive. With increased dryness thorn-woodland develops.

D. Temperate Grassland.—In the warmer temperate regions, *e.g.* South Africa and the Pampas of South America, the grassland approaches that of the tropics, but trees, when present, are usually smaller. In the colder temperate regions the grassland is meadow or steppe according to the moisture conditions.

Soils differ from one another both in physical and chemical

properties. Soil is composed of mineral matter, formed by the weathering of rocks, and decaying organic matter or humus. Other things being equal, soil composed of fine particles, *e.g.* the soil of deltas, is more fertile than that composed of larger particles. Soils may be separated into particles of different sizes which are referred to as follows :—

Fine Clay or Colloidal Clay	<0.002 mm.
Coarse Clay	0.02–0.002 mm.
Fine Sand	0.2–0.02 mm.
Coarse Sand	2–0.2 mm.
Fine Gravel	20–2 mm.
Coarse Gravel-Rock ..	>20 mm.

The amount of water which remains in a soil after any excess has drained away is termed the *absolute water-capacity*. A coarse sand has an absolute water-capacity of 13.7 per cent. of its volume, a true clay one of 40.9 per cent. The *air-capacity* of a soil is inversely proportional to water-capacity and, since good aeration is essential for root development, land which is inclined to become water-logged must be drained. Sandy soils are very *permeable*, *i.e.* they readily allow water in excess of their absolute water-capacity to drain away. Clays, however, offer considerable resistance to filtration. On the other hand, clays possess to a high degree the power of *absorbing* water by capillary conduction, as do fine soils rich in humus. In moist regions such as Western Europe clay soils absorb water beyond their absolute-capacity. Their high moisture-content makes them cold, *i.e.* they heat up slowly, and they are difficult to work on account of their stiffness. On the other hand, in drier regions such as the Mediterranean such soils are much esteemed for their power of absorbing and retaining moisture.

Important types of soil are as follows :—

1. Clay or Argillaceous Soil .. Over 50 per cent. of clay.
2. Loamy Soils 30 to 50 per cent. of clay.
3. Sandy Loams 20 to 30 per cent. of clay.
4. Loamy Sands 10 to 20 per cent. of clay.
5. Sandy Soils.. .. Over 70 per cent. of sand.
6. Marly Soils, which are further classed into clayey marls, loamy marls, etc... 5 to 20 per cent. of lime.

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7. Calcareous Soils, which are further classed into clayey calcareous soils, etc. . . . Over 20 per cent. of lime.
8. Vegetable Soils, which are further divided into clayey humus, etc. . . . Over 5 per cent. of humus

Each of the above types is described as *poor* if containing less than 0.5 per cent. of humus, *intermediate* if containing 0.5 to 1.5 per cent., and *rich* if containing 1.5 to 5 per cent.

Fine soils rich in humus and having a permeable substratum possess a degree of humidity which is generally favourable for plants. Sandy soils poor in humus and having a gravel sub-soil are generally only suitable for xerophilous plants. On calcareous soils which are poor in humus vegetation is markedly xerophilous, but if humus is present the moisture-absorbing power is much increased. Soils containing much humus and little lime are inclined to become acid, whilst those with abundant lime are alkaline. The pH of the soil may be determined by means of indicators. All plants require calcium for their normal nutrition. Certain plants, however, e.g. *Pinus pinaster* and *Digitalis purpurea*, known as calciphobous plants, cannot be grown on chalky soils probably owing to alkalinity. In other cases different varieties of the same species may grow on different soils, for example, in Derbyshire *Valeriana officinalis* var. *sambucifolia* is common on the coal measures, but avoids the limestone, where it is replaced by *Valeriana officinalis* var. *mikanii*.

Preparation of the Soil.—For details of agricultural and horticultural procedure information should be sought in some of the many books on these subjects.* The land must be cleared and tilled. The moisture in the soil may be regulated by drainage or by irrigation. Tillage operations are directed towards the breaking up and stirring of the soil to facilitate the entry of air (which increases the amount of available plant food), to assist drainage and to produce a loose, friable medium suitable for the germination of seeds and the free growth of roots. On a small scale this is done by means of the spade, fork, hoe, and rake, and on a larger scale by ploughs, cultivators, harrows, and rollers.

* The following are suggested: *The Gardener's Assistant*, Edited by W. Watson, and *A Textbook of Tropical Agriculture*, by H. A. Nicholls and J. H. Holland.

Analyses of plant ashes show that the following elements are taken from the soil: Cl, O, S, N, P, Si, Na, K, Mg, Ca, and Fe. Since plants differ in their food requirements the best results are obtained by arranging a suitable rotation of crops. When the soil becomes impoverished its fertility can be restored by allowing it to lie fallow or by the use of manures. The most important manures are those which contain nitrogen, potassium, phosphate, or lime. *Farmyard manure* is a general manure in that it contains all the elements required by the plant. In the unfermented state it is particularly useful for opening up clay soils, but for most horticultural purposes it should first be allowed to rot in heaps. Mixtures of manures and earths are known as *composts*. If growing crops are ploughed in this is called *green crop manuring*, and is well adapted to light soils as the humus produced increases the moisture capacity. Leguminous crops such as clover, and in the tropics species of *Cajanus* and *Mucuna*, are usually used for this purpose since they also increase the nitrogen-content of the soil owing to the fixation of atmospheric nitrogen. Rape and mustard are also good crops for providing quick-rotting green manure. *Special manures* are those which owe their value mainly to only one plant food, and they should therefore only be employed when the use of that particular type of food is clearly indicated. Special manures contain *nitrogen*, e.g. the guanos, ammonium sulphate, sodium, and potassium nitrates, or *phosphate*, e.g. bones, mineral phosphates, superphosphates, reduced phosphates, and basic slag, or *calcium*, e.g. lime or gypsum, or *potassium*, e.g. wood ashes, kainite, and potassium sulphate. Some of these, e.g. ammonium sulphate and sodium nitrate, are readily soluble, and since they are easily washed out of the soil they must be applied when they can exert their fullest effect on the crop. Superphosphate being acid should not be used in soils which are deficient in lime.

Propagation.—Plants may be reproduced from seed or by vegetative means.

A. From Seeds.—To ensure success the seeds must be collected when perfectly ripe. If not planted immediately, they should normally be stored in a cool and dry place and must not be kiln-dried. Some seeds such as cacao, coffee, and nutmegs rapidly lose their power of germination if allowed to dry. The quality of seeds can be judged to some extent by their size, appearance, and specific gravity. For example,

henbane seeds if fertile will sink in water. Seed samples may also be tested by sowing a few in a pot and keeping them in an incubator until they germinate. Long storage usually much decreases the percentage which germinate.

Although seeds are naturally sown at the season when they ripen it is frequently more convenient, especially in the case of the less hardy exotic species, to defer sowing until the spring. In some cases, however, immediate sowing of the fresh seed is advisable. For example, it has been shown that if the seeds of *Colchicum autumnale* are air-dried even for a few days only about 5 per cent. germinate in one year and some may not germinate for five years, whereas if sown as soon as the capsules dehisce 30 per cent. will germinate in the first year. If sowing is postponed until the spring it is advisable to soak all seeds which have hard testas in water. More drastic methods, such as soaking in sulphuric acid in the case of henbane seeds, or partial removal of the testa by means of a file or grindstone, have also been recommended. Other slow germinating seeds, which may otherwise lie in the ground for years, may, after soaking, be mixed with light soil and buried in a hole in the ground for 12 months; they are then taken up and the soil and seed mixture sown in the ordinary way.

Seeds may be sown broadcast, in drills or in holes. Small seeds, such as those of *digitalis*, may be sown broadcast as they only need raking with the soil. Generally speaking, seeds may be buried to the depth of their smallest diameter, but as a protection against birds, etc., it is sometimes advisable to sow them deeper.

B. By Vegetative Means.—The following examples of vegetive propagation may be mentioned:—

1. By the development of: bulbs, *e.g.* squill; corms, *e.g.* colchicum; tubers, *e.g.* jalap and aconite; or rhizomes, *e.g.* ginger.

2. By *division*, a term usually applied to the separation of a plant which has a number of aerial stems or buds into separate parts each having roots and a growing point. This method may be used for althæa, rhubarb, gentian, and male fern.

3. By *runners* or *offsets*, *e.g.* chamomile and the mints.

4. By *suckers* or *stolons*, *e.g.* liquorice and valerian.

5. By *cuttings* or portions of the plant severed from the plants capable of developing roots. Generally speaking, cuttings of hard-wooded plants should be inserted in autumn and of soft-wooded plants in spring. The shoots may be cut

off or torn off so as to leave a heel which should be trimmed. Soft-wooded cuttings should be exposed to the air for an hour to dry the sap. The lower leaves are removed and the cuttings placed in a suitable medium. A mixture of silver sand and fine soil is usually suitable. A moist atmosphere and a temperature a few degrees higher than that at which the plant normally grows favour root development. Cuttings may be employed for the propagation of mints, lavender, coca, and vanilla. See also "Plant Hormones" below.

6. By *layers*. A layer is a branch or shoot which is induced to develop roots before it is completely severed from the parent plant. This is done by partly interrupting the food supply by means of a cut or ligature and embedding the part so treated in the soil. If the branch is one which cannot be bent to ground level the necessary soil may be contained in a raised plant pot or tin having a slit in one side for the entry of the branch. We have successfully used this method for the propagation of cascara. In September one of the lower branches of a small cascara tree was about half-severed by means of an oblique cut. It was pegged down and the cut covered with soil. By March good roots had developed and the new plant was separated. Clove trees are sometimes propagated by layering.

7. By *grafting and budding*. Grafting is an operation in which two cut surfaces, usually of different but closely related plants, are placed so as to unite and grow together. The rooted plant is called the *stock* and the portion cut off the *scion* or *graft*. Grafting of female scions of *Myristica fragrans* on male stocks may be used to increase the proportion of fruit-bearing trees. *Budding* consists of the introduction of a piece of bark bearing a bud into a suitable cavity or T-shaped slit made in the bark of the stock. Budding is largely used for *Citrus* species, selected strains of sweet orange, for example, being budded on sour stocks.

Plant Hormones.—It has recently been shown that certain growth-promoting substances such as indolylbutyric acid, heteroauxin, α -naphthalene acetic acid and β -indolylacetic acid are able to accelerate the rooting of cuttings. Such substances are now marketed as proprietary articles. It is possible by placing the cuttings for 24 hours in dilute solutions, about 1 in 20,000 to 1 in 50,000, to root cuttings of hardwood trees such as the hollies, which formerly had to be grafted or raised from seed.

Notes on Plants Suited to a Temperate Climate

Aconitum Napellus grows in any ordinary soil but prefers a moist loam and a shady situation. Propagation by means of daughter roots planted out in January is preferable to raising the plants from seed (see p. 349).

Althæa officinalis grows best in a clay loam in an open situation. Propagation is by division of old roots or from seeds sown in early spring in drills about 3 feet apart.

Anthemis nobilis prefers a damp, peaty loam and a sunny situation. Since the seeds produce the single variety vegetative propagation is the best. In March soil is sifted round the trailing offsets, and when these have rooted each old plant is divided into about ten parts. The latter are planted out in rows about 2½ feet apart with a distance of 18 inches in the rows.

Atropa Belladonna prefers a light permeable soil with a chalky subsoil, but grows in heavier soils if the drainage is satisfactory. It may be propagated by division of the old roots in April or from seed. The seeds take about six weeks to germinate and may be sown in spring in rows about 3 feet apart. It is advisable to sow some also in sterilised soil in a frame and plant out the seedlings in May, where gaps occur in those sown in the open.

Carum Carvi is a biennial which is grown in the South of England in light, warm soil. The fresh, ripe fruits are sown in the autumn or in March or April in drills 10 inches apart. The fruits are ripe in July or August of the following year.

Colchicum autumnale is grown in damp, preferably calcareous soil. The plant may be propagated by means of the daughter corms or by seed. The seed, preferably fresh, may be sown out-of-doors or in a cold frame. When two years old the plants should be transplanted to about 3 inches apart.

Coriandrum sativum is an annual which is readily grown from ripe fruits sown in April.

Datura Stramonium prefers a rich calcareous soil to which burnt bonfire refuse may be added with advantage. The seed is sown in May in very shallow drills about 3 feet apart. The plants are subsequently thinned out to about 12 to 15 inches in the row.

Digitalis purpurea grows well in a well-drained, loose soil which is rich in humus but non-calcareous. To ensure even distribution when sowing the small seeds may be mixed with sand. The plant requires a moderate amount of sun.

Dryopteris Filix-mas prefers a rich, moist loam and shade. It may be propagated by division or from the spores. The spores are collected by placing a ripe frond on a piece of paper, spore side downwards, and covering it with a sheet of glass. A small pot is then filled with a compost of loam and leaf mould and sterilised by pouring boiling water through it until the whole has been thoroughly heated. When cold, the spores which have collected on the paper are scattered over the surface of the compost and the pot covered with a sheet of glass. After standing for a few weeks in a shady position the prothalli which develop may be pricked out into other pots prepared in a similar way. When sufficiently large the young ferns are planted out.

Foeniculum vulgare will grow in dry and stony situations, but yields a better crop of fruit on a deep, rich, and rather stiff soil. The fruits are sown from February to April in shallow drills 15 inches apart, the plants being afterwards thinned out to 1 foot apart in the rows. Alternatively they may be raised in a seed bed and planted out when 3 or 4 inches high.

Gentiana lutea requires a moist, cool situation with good drainage. A suitable soil consists of a mixture of loam, peat, and grit. The plant may be propagated by division or from seed.

Glycyrrhiza glabra grows best in a deep, rich, rather sandy loam, which should be free from stones. The land should be deeply trenched and manured in the autumn, and the stolons planted in February 18 inches apart with 3 feet between the rows. In November the aerial stems should be cut off and the stolons near the surface forked up and cut off near the crown. The stolons may be preserved in sand and used for planting in dry weather in the following February or March. The drug is usually collected in the third year by digging a trench about 3 feet deep and pulling up the plants by means of a rope attached near the crown.

Hyoscyamus niger forms a somewhat uncertain crop. If the seed has been kiln-dried it is useless for sowing. On the commercial scale only the biennial plant is grown. As germination is slow the seeds should be sown either in September for germination in the following year or in April, when they should be well soaked or buried in moist sand prior to sowing. The plants cannot be transplanted successfully and must be sown in the open. They grow in most soils, but prefer a light, well-drained soil and an open, sunny position. The land should be

manured and be kept moist until the seeds have germinated and the plants made some growth. The seeds, mixed with sand or fine soil, are sown in rows about 2 to 2½ feet apart, the plants being afterwards thinned out to a distance of 2 feet in the rows. The terminal buds of henbane are often destroyed by caterpillars.

Lavandula officinalis grows well in sunny positions in light, rather dry soils well supplied with lime. In a rich, moist soil it is less resistant to frost and is less aromatic. Lavender is easily propagated by taking green wood cuttings about 3 inches long in April and inserting them in damp soil in a cold frame. They may be planted out in the following October or spring. Old plants should be pruned in March or April.

Mentha piperita and *Mentha viridis* prefer a moist soil, and are easily propagated by digging up the rhizomes in early October, cutting off all aerial stems to eliminate the risk of "Mint Rust," and before replanting washing well to remove all old soil and rust spores. Plant in fresh soil, covering the rhizomes about 1 inch deep. If rust appears on old plants, cover these with straw on a dry day in late September and set fire to the straw. This will destroy rust, but will not injure the underground stems if burning is rapid.

Papaver somniferum requires a rich, moist soil and plenty of sun. Considerable quantities are grown for their capsules in Lincolnshire. The seeds are sown in March or April in drills 1 foot apart. When about 4 inches high the plants are cut into clumps about 8 inches apart and the plants in each clump reduced to one. The capsules are harvested about September.

Rheum Spp.—Rhubarbs like a rich, deep soil which should be deeply trenched and treated with well-rotted manure. Ordinary garden rhubarbs are said to be derived from *Rheum rhaponticum* and *R. undulatum*, but *R. officinale*, *R. emodi*, and *R. palmatum* var. *tanguticum* can also be purchased. Rhubarbs are propagated by dividing the crowns in early spring into a number of pieces each bearing a bud. They may also be grown from seed sown in the spring.

Valeriana officinalis var. *mikanii* and var. *sambucifolia* are grown as described on p. 622. Not only should the land be manured before planting, but good results are obtained by the subsequent application of liquid manure.

Notes on Plants Suited to the Tropics or Subtropics

Capsicum frutescens is a small shrub which in a hot climate is readily grown from seed. For their successful growth in England a greenhouse is necessary. The plant prefers a light loamy soil.

Cephaelis Ipecacuanha is a small shrub the commercial cultivation of which outside Brazil only appears to have succeeded in the Straits Settlements. The plant needs a rich, well-drained soil, a fairly heavy uniformly distributed rainfall, and shade. *Ipecacuanha* may be propagated from pieces of root and by cuttings and layers.

Cinchona Spp.—The cultivated species of *Cinchona* need a rich open soil and a well-drained sub-soil. A deep vegetable loam with a gravel sub-soil is usually preferred. The rainfall should be about 50 to 100 inches and the mean temperature about 65°. Different species grow at altitudes of from about 1,000 to 6,000 feet. The trees need protection from strong winds which may be provided by shelter belts of other trees. Propagation is usually by means of seeds. The plants are raised in nurseries and afterwards hardened and planted out at suitable intervals. *Cinchonas* may also be grown from cuttings or by the layering of branches.

Cinnamomum zeylanicum grows well in almost any tropical soil, but prefers a sandy soil rich in humus. The plants may be raised in nursery beds or the seeds may be sown in the open in groups of about five at intervals of 6 feet. Fresh seed is essential. Cinnamon may also be propagated by cuttings or by layering.

Elettaria Cardamomum grows naturally in the monsoon-forests of Malabar at a height of about 1,800 to 3,500 feet. It prefers a rich loam and needs shade. When the Malabar jungle is partly cleared wild cardamom plants soon occupy the clearings. Under cultivation propagation may be by means of seed, which is germinated in nurseries and the seedlings afterwards planted out at intervals of 6 feet, or by division of the rhizomes.

Erythroxylon Coca grows on mountain slopes in the tropics. It requires a rich, moist, loamy soil. Plants may be raised in nurseries from seed or by means of cuttings.

Eugenia aromatica, although grown in islands such as Zanzibar and Pemba, will not stand exposure to salt winds. It grows well up to about 1,000 feet, preferring well-drained

slopes of clayey loam. Cloves may be propagated by means of seed, which must be fresh, or by layering the young branches.

Ipomœa purga grows naturally in moist, shady woods at an altitude of 5,000 to 8,000 feet where the day temperatures are about 60° to 70°. It likes a well-drained, rich, sandy loam, and a more or less uniformly distributed heavy rainfall. Jalap may be propagated by planting out the smaller tubercles or cuttings of the underground stems.

Myristica fragrans is a lowland plant which requires a hot, moist climate. It prefers a deep, friable loam with good drainage. The seeds, which must be fresh, are planted in nursery beds about 1 inch deep and 1 foot apart. When kept moist, seedlings appear in about forty days, and on attaining a height of 2 or 3 feet are planted out at a distance of about 25 feet from one another. Frequently the plants are arranged in pairs, so that if one subsequently proves to be male it can be destroyed. When flowers appear the sexes of the trees are determined, and only about 10 per cent. of the male trees are retained for pollination. The remainder may be cut down or their sex altered by using them as a stock and grafting them with scions from female trees.

Piper nigrum grows best in a moist tropical climate with an evenly-distributed rainfall. Since the pepper is a climbing plant support must be provided either by posts or trees. The vines are grown from seed or from cuttings.

Ricinus communis is an annual in temperate climates, but in the tropics it is a perennial tree which may attain a height of 25 feet. It is easily grown from seed and prefers a well-drained, loamy soil.

Vanilla planifolia needs a moist tropical climate and a rich vegetable soil. The plant is grown on posts or on living trees such as *Casuarina equisetifolia* and *Jatropha Curcas*. It is propagated by means of cuttings.

Zingiber officinale may be grown on rich soil in the tropics and subtropics from sea-level up to about 5,000 feet. A well-drained, rich clayey loam is suitable. In March or April the soil is raised in ridges about 3 feet apart. Small holes are made in the ridges at intervals of about a foot and partly filled with well-rotted manure. A piece of rhizome bearing a bud is then placed in each hole at a depth of about 3 inches and is covered with soil. For further information, see p. 265.

CHAPTER VI

THE COLLECTION, DRYING, AND STORAGE OF DRUGS

THE preparation of each drug for the market depends on its morphological nature, its constituents, the geographical source, and other factors. In the following pages the chief points to be observed in the collection, drying, and storage of drugs are indicated in a general way.

Collection.—Drugs may be collected from wild or cultivated plants. Collection may be undertaken by casual, unskilled native labour, *e.g.* ipecacuanha, or by skilled workers in a highly scientific manner, *e.g.* digitalis, belladonna, and cinchona. Although some firms in England cultivate certain of their own drugs, the amount so grown is relatively small, since foreign-produced drugs are generally cheaper and buyers are not prepared to pay a higher price. This is to be regretted since the quality of the imported drug is often so much inferior to the home-grown. Research, for example, in plant breeding, and the scientific control of the cultivation, collection, drying and storage of drugs will do much to improve the quality of the medicaments derived from them.

The season at which each drug is collected is usually a matter of considerable importance, since the amount, and sometimes the nature, of the active constituents is not constant throughout the year. This applies, for example, to the collection of podophyllum, ephedra, rhubarb, and aconite. Not only is the month of collection important, but in certain cases it may be necessary to take the time of day into consideration. Wasicky and co-workers have in recent years done a considerable amount of research on this subject. They find, for example, that rhubarb contains no anthraquinone derivatives in winter, but contains anthranols which, on the arrival of warmer weather, are converted by oxidation into anthraquinones. Wasicky has also shown that in digitalis leaves the active glycosides split off sugar during the night, the

aglucone recombining next day with sugar when carbon assimilation has taken place. As the aglucones are much less active therapeutically than the glycosides the collection of the leaves in the afternoon is indicated.

Generally speaking, leaves are collected as the flowers are beginning to open, flowers just before they are fully expanded, and underground organs as the aerial parts die down. Leaves, flowers, and fruits should not be collected when covered with dew or rain. Any which are discoloured or attacked by insects or slugs should be rejected. Even with hand-picking it is difficult, certainly expensive, to get leaves, flowers or fruits entirely free from other parts of the plant. In such cases as *Belladonna*, *Stramonium*, *Hyoscyamus*, *Buchu*, *Sennæ Folium*, and *Caryophyllum*, the Pharmacopœia allows a certain percentage of stalks to be present. Similarly with roots and rhizomes a certain amount of aerial stem is often collected and is officially permitted in the case of *Senega*, *Serpentaria*, and *Ipecacuanha*. The harvesting of umbelliferous fruits resembles that of corn. Reaping machines are used and the plants, after drying in shocks, are threshed to separate the fruits. Barks are usually collected after a period of damp weather, as they then separate most readily from the wood. For the collection of gums, gum-resins, etc., dry weather is obviously indicated, and care should be taken to exclude vegetable debris as far as possible.

Underground organs must be freed from soil. Shaking the drug before, during, and after drying, or brushing it may be sufficient to separate a sandy soil, but in the case of a clay or other heavy soil, washing is necessary. For example, valerian is washed in the streams on the banks of which it usually grows. Before drying, any wormy or diseased rhizomes or roots should be rejected. Those of small size are often replanted. In certain cases the rootlets are cut off; and rhubarb, ginger, and marshmallow are usually peeled. All large organs, such as calumba root and inula rhizome, should be sliced to facilitate drying. Before gentian root is dried it is made into heaps and allowed to ferment. Seeds such as *nux vomica* and cocoa, which are extracted from mucilaginous fruits, are washed free from pulp before drying.

Drying.—If enzyme action is to be encouraged, slow drying at a moderate temperature is necessary. Examples of this will be found elsewhere under orris rhizome, vanilla pods, cocoa seeds, and gentian root. If enzyme action is not desired,

drying should take place as soon as possible after collection. Drugs containing volatile oils are liable to lose their aroma if not dried or the oil distilled from them immediately, and all moist drugs are liable to develop mould. For these reasons drying apparatus and stills should be situated as near to the growing plants as possible. This has the further advantage that freightage is much reduced, as all fresh drugs contain a considerable amount of water. The amount of dried drug obtained from 100 parts of certain fresh plants is shown in the following table :—

Chamomile flowers ..	25-33 parts	Belladonna root ..	33-38 parts
Rose petals ..	10 "	Gentian root ..	25 "
Bearberry leaves ..	20 "	Liquorice root ..	30-33 "
Belladonna leaves ..	15-25 "	Male fern rhizome ..	30-32 "
Digitalis leaves ..	25-34 "	Rhubarb rhizome ..	25-34 "
Henbane leaves ..	14-20 "	Valerian rhizome ..	22-25 "
Stramonium leaves ..	30-33 "		

The duration of the drying process varies from a few hours to many weeks, and in the case of open-air drying depends very largely on the weather. In suitable climates open-air drying is used for such drugs as clove (Fig. 22), colocynth, cardamom and cinnamon. Even in warm and dry climates arrangements have to be made for getting the drug under the cover of sheds or tarpaulins at night or during wet weather. Such drying as is done in England without artificial heat is carried out in sheds or barns, with the exception of dill and peppermint, where preliminary drying, at any rate, takes place in the fields. Within the sheds the drugs may be suspended in bundles from the roof, threaded on strings, as in the case of Chinese rhubarb, or, more commonly, placed on trays made of sacking or tinned-wire netting. Papers spread on a wooden framework are also used, particularly for fruits from which it is desired to collect the seeds.

Drying by artificial heat is more rapid than open-air drying and more suitable for use in this country. Sheds of various types and brick buildings are used. The actual drying-chamber is preferably on the ground level, while the heating apparatus is sunk below it. Heat may be applied by means of open fires (*e.g.* nutmegs), stoves, or hot-water pipes. In all drying sheds there must be a space of at least 6 inches between super-imposed trays and air must circulate freely. For small quantities stoves supporting a number of trays will be found suitable, or if rapid drying at the lowest possible

temperature is required a vacuum dryer may be used.* In all cases care must be taken that each tray or shelf contains only one kind of drug and only drugs requiring similar treatment should be dried at any one time.

Fairly rapid drying helps flowers and leaves to retain their colour and aromatic drugs their aroma, but the temperature used in each case must be governed by the constituents and



FIG. 22.—Cloves drying on mats. Government Plantations, Lupani, Pemba.

(From the Imperial Institute Collection.)

the physical nature of the drug. As a general rule, leaves, herbs, and flowers may be dried between 20° and 40° , and barks and roots between 30° and 65° . In the cases of colchicum corm and digitalis leaf it will be noted that the Pharmacopœia specifies the temperatures at which drying is to be done.

Exactly how far drying is to be carried is a matter for practical experience. If leaves and other delicate structures

* See Bentley's *Text-book of Pharmaceutics*, Fig. 27.

are overdried, they become very brittle and tend to break in transit. Drugs such as aloes and opium may require further drying on arrival in Britain.

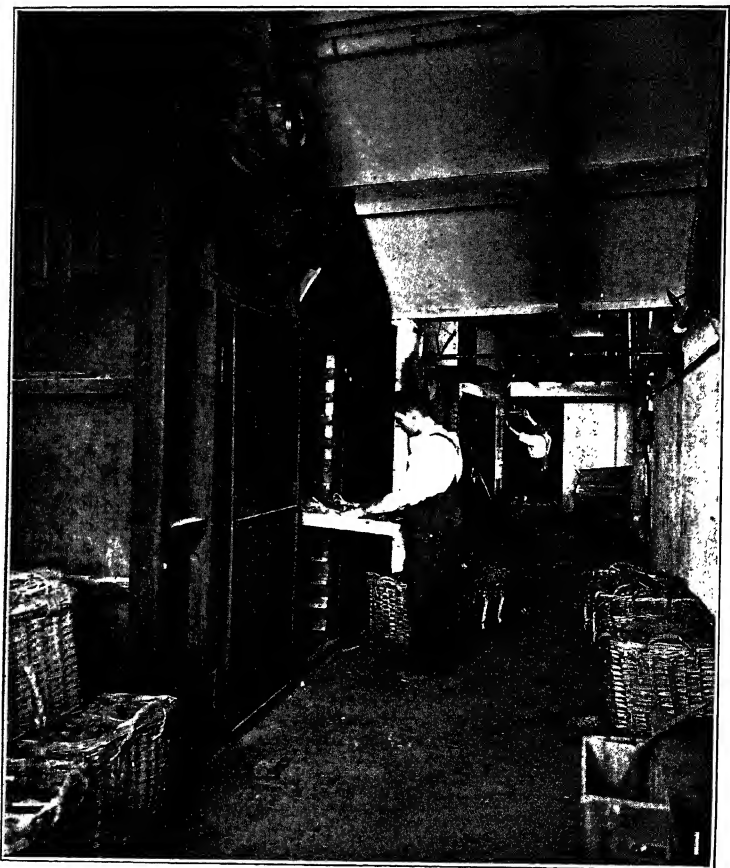


FIG. 23.—View of drying room, Stafford, Allen & Sons' Works, Long Melford.

Storage.—Except in a few cases, such as cascara bark, long storage, although often unavoidable, is not to be recommended. Drugs such as Indian hemp and sarsaparilla deteriorate even

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when carefully stored. Drugs stored in the usual containers—sacks, bales, wooden cases, cardboard boxes, and paper bags—reabsorb about 10 to 12 per cent. or more of moisture. They are then termed "air-dry." The permissible moisture-contents of starch and acacia gum will be found in the Pharmacopœia. Air-dry drugs are always liable to the attack of insect and other pests (see next chapter). Drugs should be frequently examined during storage, and any showing mould or worminess should be either rejected or treated as described in the next chapter.

Drugs such as digitalis and Indian hemp should never be allowed to become air-dry or they lose a considerable part of their activity. They may be kept in sealed containers with a dehydrating agent. For large quantities the bottom of a case may be filled with quicklime and separated from the drug by a perforated grid or sacking. If the lime becomes moist it should be renewed. Volatile oils should be stored in sealed, well-filled containers in a cool, dark place. Similar remarks apply to fixed oils, particularly cod-liver oil. In the latter case the air in the containers is sometimes replaced by an inert gas.

Low temperature storage is a good way of controlling insect attack in drugs. An interesting report (1933),* on moths which have caused considerable damage to tobacco, cocoa, etc., stored in London, shows that adult moths, pupæ, larvæ, and eggs are destroyed by low temperature storage. It was found that the eggs were the most resistant to cold and that the eggs of *Ephestia elutella* were less resistant than those of *E. kühniella* as may be seen from the following figures:—

		<i>E. elutella</i>	<i>E. kühniella</i>
At -15°	no eggs survived after ..	12 hours.	60 hours.
At -10°	" " " ..	18 "	75 "
At -6° to -7°	" " " ..	about 150 "	264 "
At -3° to -4°	" " " ..	168 "	336 "

The destruction of *Ephestia* in tobacco by means of steam or by fumigation with ethylene oxide was also investigated.

* See Report of the Empire Marketing Board, No. 67: The Infestation of Cured Tobacco in London by the Cacao Moth, *Ephestia elutella*. Also F.M.B. Report No. 24: Insect Infestation of Stored Cocoa, and E.M.B. Report No. 29: The Biological Control of Insect and Plant Pests; and U.S. Dept. of Agriculture Farmers' Bulletin, No. 1353: Clothes Moths and their Control.

CHAPTER VII

INSECT AND OTHER PESTS IN DRUGS

MEDICINAL plants and air-dry drugs are liable to attack by true insects, particularly the Coleoptera, or beetles, and the Lepidoptera, or moths. Arachnids, particularly the Tyroglyphidæ or mites, fungi, and bacteria also cause considerable damage.

The drug-room beetle, *Sitodrepa panicea* (Fig. 24), is a brown beetle 2 to 3 mm. in length. Like other insects it possesses a

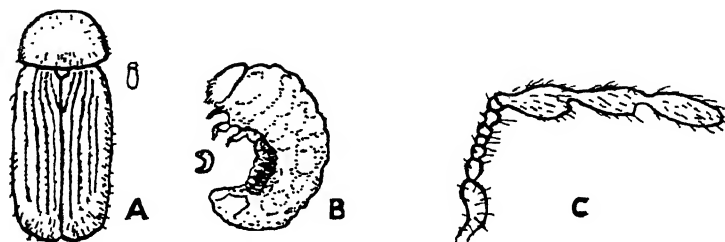


FIG. 24.—*Sitodrepa panicea*. A, mature insect; B, larva (smaller figures indicate actual size); C, antenna $\times 50$.

pair of antennæ and three pairs of legs, while a pair of membranous wings and a pair of hard wing-cases show that it is a member of the Coleoptera, or beetles. When disturbed the insect feigns death and draws the antennæ and legs under the body. The front of the thorax is extended over the head as a hood; next comes the mesothorax to which are attached the elytra or wing-cases, followed by the metathorax bearing the membranous wings; and lastly the abdomen. The head and prothorax are somewhat darker than the other regions, which are a bright yellowish-brown. All the exposed parts are covered with simple hairs, while the wing cases bear about seven longitudinal lines of rounded or oval markings, each having a central slit. These are surrounded by granules of

undetermined nature. The three outermost joints of the antennæ are larger than the preceding ones.*

Although *Sitodrepa panicea* is perhaps the commonest beetle found in drugs, other species of Coleoptera are quite common. Of these the cigarette beetle, *Lasioderma serricorne* (Fig. 25, A), closely resembles the drug-room beetle, but it can be distinguished from the latter by the lack of striations on the wing-cases. The granary beetle, *Niptus hololeucus* (Fig. 25, B), is brown in colour and larger than the drug-room beetle. *Ptinus fur* (Fig. 25, C) and *Ptinus brunneus* are well-known

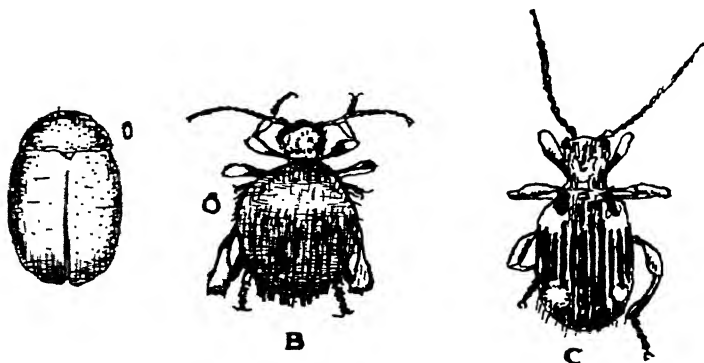


FIG. 25.—A *Lasioderma serricorne*; B, *Niptus hololeucus*; C, *Ptinus fur*. The smaller figures indicate actual size. (After Tschirch.)

household insects which have been found in drugs such as senna, capsicum, sumbul, and jaborandi.

In the Lepidoptera or moths the insect passes through a larval or caterpillar stage in which it is provided with strong jaws for eating dry food. This is succeeded by a non-motile pupal stage from which the mature moth develops. As in the case of the household clothes-moth, a member of the genus *Tinea*, damage to drugs is caused by the larvæ and not the mature insect. The larvæ of *Ephestia kühniella* (Fig. 26, A–C), *Tinea cloacella* (Fig. 26, D), *Corcyra cephalonica* and *Borkhausenia pseudo-spretella* have been found in drugs. Aconite root seems somewhat liable to attack by these pests. Their attacks on tobacco and cocoa and the effect of low temperature storage are described on p. 68.

* For further details, see Greenish and Braithwaite, *P.J.*, 1910, p. 580.

The members of the Tyroglyphidæ, e.g. *Tyroglyphus siro*, the common cheese-mite (Fig. 26, E), are much smaller than the beetles. In the larval stage six legs are present, but in the mature insect there are eight. Apart from the legs there is little difference in the two stages. The mites tear drugs to pieces by means of their powerful mandibles. Some mites are carnivorous and live on the smaller vegetarian members of their own order or on other insects. According to Sayre, at

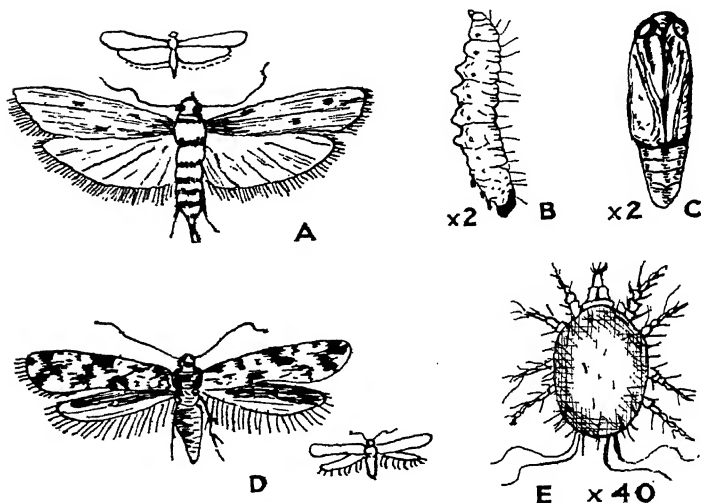


FIG. 26.—A, *Ephestia kühniella*; B, larva of same; C, pupa of same; D, *Tinea cloacella*; E, *Tyroglyphus siro*. (A and D after Tschirch; B and C after Wallis; E after Sayre.)

least half a dozen species of mite attack cantharides. They also commonly attack flour and such drugs as ergot, quince, and linseed.

Although "wormy" drugs may not be injurious to health, reputable houses will always endeavour to deal in drugs which have not been so attacked. Inferior qualities may, however, be sold in the form of powder, and an examination of a powdered drug for insect remains, may throw considerable light on the quality.

The prevention and limitation of insect attack deserves

the serious attention of all who handle drugs. Attention should be directed to prevention rather than to cure, and it is frequently better to sacrifice a "wormy" drug than to risk the contamination of other samples. Protection is afforded by keeping the drug perfectly dry or by dusting it with lime. Liming is often used for the protection of nutmegs and ginger, the lime choking the delicate air-tubes of both the larvæ and mature insects.

Infected drugs are difficult to free completely from insects. Eggs, larvæ, and insects may be destroyed by heating above 60°, the period of heating varying from fifteen minutes to several days, according to the nature and quantity of the drug being treated. For small samples, such as museum specimens, treatment with the vapour of chloroform, carbon disulphide, or carbon tetrachloride is fairly successful, but when large quantities are so treated only about half the larvæ and few, if any, of the eggs are destroyed. Much, no doubt, depends on the season at which the treatment is applied. Holmes recommends it to be done, if possible, in April or May, before the insects assume the imago or mature state.

Low temperature storage is preferable to the use of lime and toxic vapours, and is now being employed for the protection of drugs.

PART II
MICROSCOPY

CHAPTER VIII

APPARATUS AND REAGENTS

THE apparatus required for work in pharmacognosy will include a scalpel or knife, a pocket lens, a camel-hair brush, forceps, dissecting scissors, and a duster and glass cloth. For section cutting a good razor is essential, and it is false economy to buy a cheap one. It is impossible to get one razor which is equally suited to all the different types of work encountered, and for second-year students two razors are advised. One, flat or only slightly hollow-ground for obtaining rather large sections of stems, barks, etc., and a second hollow-ground shaving razor for very thin sections of soft tissues such as leaves, where a large area of preparation is not required. Each worker will also require glass slides, cover-glasses, a micro-Bunsen burner or spirit lamp, and a set of reagents.

Microscopes and Lamps.—A microscope suitable for pharmacognostical work is illustrated in Fig. 27. For students' work the microscope is usually fitted with two objectives, $\frac{2}{3}$ in. (16 mm.) and $\frac{1}{8}$ in. (4 mm.), two eyepieces, and a condenser. The magnification obtained depends not only on the objective and eyepiece used but may be increased by lengthening the draw-tube. The standard length of draw-tube should, however, normally be used.

Many types of electric lamp are available as sources of

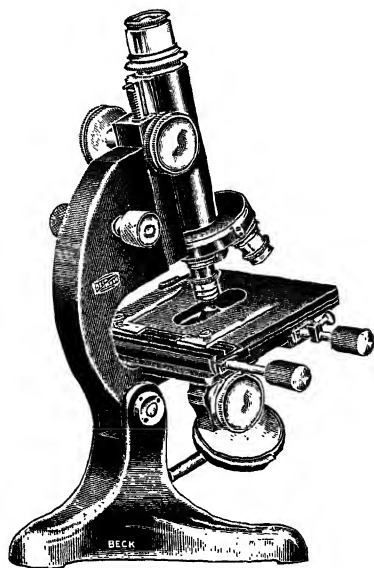


FIG. 27.—London Microscope (R. and J. Beck, Ltd.)

illumination, but the simple type illustrated by Wallis * will be found very satisfactory, and its flat top is useful for heating microscope slides. Many students make the error of over-illuminating the object. This is not only tiring to the eye but does not show up the object to the best advantage. The slide should first be viewed with a low-power objective, the condenser being some distance from the object so that the whole field is evenly lighted. Next the high power is used, the light being concentrated on a smaller field by raising the condenser. The change in size of the field with different objectives and eyepieces is shown below.

Magnification and Field of View.—Objectives are known



FIG. 28.—Huyghenian eyepiece fitted with micrometer (C. Baker).



FIG. 29—Eyepiece micrometer (J. Swift & Son, London).



FIG. 30.—“Telaugic” eyepiece (J. Swift & Son, London).

by their focal length, *e.g.* 16 mm. Since the objective is not a single lens, the focal length is measured from a point somewhere between the front and back surfaces of the component lenses and the distance between the front lens and the object in focus, *i.e.* *working distance*, is thus less than the focal distance. A 16-mm. objective has a working distance of about 6.2 mm. and a 4-mm. objective a working distance of about 0.5 mm. With low powers the thickness of the cover-glass is of little importance, but with the 4 mm. and higher powers only the thinnest should be used, as these objectives are adjusted to give the best image when used with No. 1 cover-glasses. The thickness of No. 1 cover-glasses is about 0.15 mm., No. 2 about 0.2 mm., and No. 3 about 0.25 mm.

* *Practical Pharmacognosy*, p. 3.

The commonly used Huyghenian eyepiece consists of two plano-convex lenses mounted at a suitable distance from one another and having a diaphragm between them for supporting a micrometer when the latter is required (Figs. 28 and 29). Those magnifying the initial image, produced by the objective, about 6 and 10 times will be found useful.*

<i>Focal Length.</i>	<i>Approximate Magnifying Power.</i>
42 mm.	× 6
25 mm.	× 10
17 mm.	× 15

An approximate idea of the magnification and field of view to be expected with different objectives and eyepieces is given below :—

<i>Focal Length of Objective.</i>	<i>Initial Magnifying Power.</i>	<i>Approximate Magnification with Eyepiece.†</i>		
		× 6	× 10	× 15
16 mm. ($\frac{3}{8}$ in.)	10	62	110	155
4 mm. ($\frac{1}{8}$ in.)	45	285	490	690

<i>Focal Length of Objective.</i>	<i>Approximate Field of View with Eyepiece.‡</i>		
	× 6	× 10	× 15
16 mm. ($\frac{3}{8}$ in.)	2.0 mm.	1.1 mm.	0.89 mm.
4 mm. ($\frac{1}{8}$ in.)	0.5 mm.	0.25 mm.	0.21 mm.

When using the microscope it is useful to know the size of the field of view. For instance, if we know that using a 4-mm. objective and a × 6 eyepiece our field of view is approximately

* For those who wear spectacles more comfortable observation is obtained by the use of a "telaugic" eyepiece (Fig. 30). This gives a large, flat field and an increased distance of eyepoint, so that the spectacles do not catch on the eyepiece.

† These magnifications only apply for a tube length of 160 mm. For every 20 mm. extension of the draw-tube an additional magnification of about 10 to 15 per cent., varying with the lenses used, is obtained.

‡ The size of the field with any particular combination of lenses may be readily determined by means of a stage micrometer.

0.5 mm., or 500 μ , the size of objects such as the *Aracnoidiscus* diatom in agar (100 to 300 μ) or the large rosette crystals of calcium oxalate in rhubarb (up to 200 μ) may be roughly estimated. For accurate measurement, however, the eyepiece micrometer or camera lucida is used.

Apparatus for making Microscopical Measurements and Drawings to Scale.—Microscopical measurements may be made either by means of a stage micrometer and an eyepiece micrometer or by means of a stage micrometer and camera lucida.

Micrometers.—Two scales are required, known respectively as a *stage micrometer* and an *eyepiece micrometer*. The stage micrometer is a glass slide 3 in. \times 1 in. with a scale engraved on it. The scale is usually 1 or 1.1 mm. long and is divided

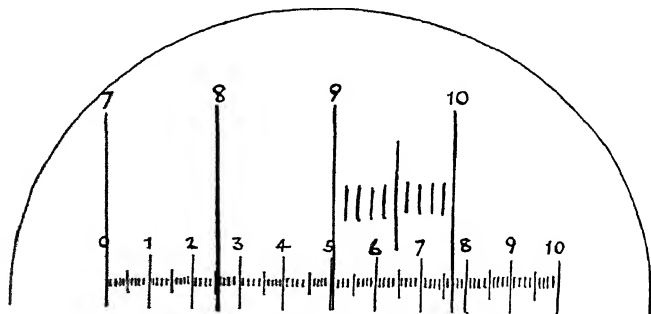


FIG. 31.—Superimposed micrometer scales.

into 0.1 and 0.01 parts of a millimetre. The eyepiece micrometer may be a linear scale of 10 mm. divided into 1 mm. and 0.1-mm. parts (*i.e.* smaller scale in Fig. 31) or may be ruled in squares of 1 mm., 0.5 mm., or 0.25 mm. The value of one eyepiece division is determined for every optical combination to be used, a note being made in each case of the objective, eyepiece, and length of draw-tube.

To do this, unscrew the upper lens of the eyepiece, place the eyepiece micrometer on the ridge inside, and replace the lens. Put the stage micrometer on the stage and focus it in the ordinary way. The two micrometer scales now appear as in Fig. 31. If exact coincidence of graduations on the two scales has not been obtained, the draw-tube may be extended until an accurate reading is possible. In the example figured,

APPARATUS AND REAGENTS

it will be seen that when the 7 line of the stage micrometer coincides with the O of the eyepiece the 10 of the stage coincides with 7.7 of the eyepiece. Since the distance between 7 and 10 on the stage scale is 0.3 mm., 77 of the small eyepiece divisions equal 0.3 mm. or 300μ ; therefore 1 eyepiece division equals $300/77$ or 3.9μ . For accurate work the eyepiece, Fig. 32, fitted with a vernier scale, Fig. 33, may be recommended.

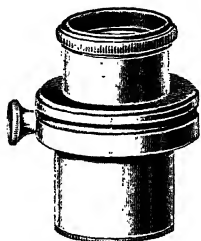


FIG. 32.—Micrometer eyepiece with vernier scale (R. & J. Beck, Ltd.).

FIG. 33.—Vernier scale micrometer showing object 3.25 mm. long (R. & J. Beck, Ltd.).

Camera Lucida.—Various forms of apparatus have been designed so that a magnified image of the object under the microscope may be traced on paper. Of these the Swift-Ives camera lucida and the Abbé drawing apparatus may be mentioned. The former is particularly suitable for students'

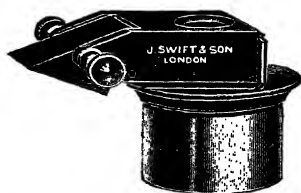


FIG. 34.—Swift-Ives camera lucida (J. Swift & Son, Ltd.).

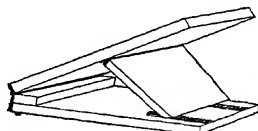


FIG. 35.—Drawing board (R. & J. Beck, Ltd.).

use on the grounds of price, compactness, and durability. This instrument (Fig. 34) fits over the eyepiece. When in use light from the object passes direct to the observer's eye through an opening in the silvered surface of the left-hand prism (Fig. 36). At the same time light from the drawing paper and pencil is reflected by the right-hand prism and by the silvered surface

so that the pencil appears superimposed on the object, which may thus be traced.

When using the instrument, the illumination of both object and paper must be suitably adjusted and the paper must be tilted at the correct angle to avoid distortion. The correct position of the drawing-board * to which the paper is pinned is found as follows: Place a stage micrometer on the microscope stage and trace its divisions on the paper. Measure the distances between the lines drawn, and if they are unequal tilt

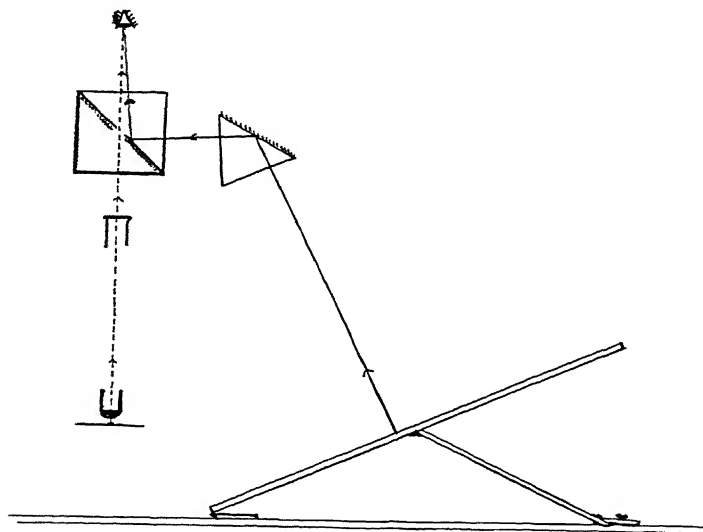


FIG. 36.—Diagram showing use of camera lucida and drawing board.

the board and repeat the tracing and measuring until all the lines are equally spaced.

To make measurements or scale drawings trace first the stage micrometer and then, using the same objective, eyepiece, and length of draw-tube, trace the object.

Example 1.—The tracings of the 0.1-mm. divisions of the micrometer were 25 mm. apart. Therefore the magnification

* For details of a suitable hinged drawing-board which may easily be adjusted to the correct angle, see Kay, *P. J.*, July, 1937, 3. In this the base-board is continued and the position in which the microscope is placed may be marked on it (see Fig. 36).

of drawing was $25 \div 0.1 = 250$. Some lycopodium spores were sketched and the mean diameter of their tracings was 7 mm., or $7,000\mu$. As the magnification is 250, the actual mean size of the spores is $7,000 \div 250 = 28\mu$. Thus the spores have been measured and sketches made of them at a magnification of 250.

Example 2.—Using the same lenses and length of draw-tube as above, the trace of an *Arachnoidiscus* diatom had a diameter of 4.3 cm. Its actual size was therefore $43,000 \div 250\mu = 172\mu$.

Example 3.—To show the affect of lengthening the draw-tube, this was pulled out about 2 cm. The tracings of the 0.1-mm. divisions were then 3.1 cm. apart, *i.e.* the magnification had increased from 250 to 310. The same *Arachnoidiscus*



FIG. 37.—Polariser (C. Baker).



FIG. 38.—Analyser to fit nosepiece (C. Baker).



FIG. 39.—Analyser to fit eyepiece (C. Baker).

diatom was again traced and the diameter of the sketch increased from 4.3 to 5.4 cm. Its size was therefore $54,000 \div 310\mu = 174\mu$, which agrees with the figure obtained in Example 2. It will be evident that any alterations made in the length of the draw-tube must be accompanied by a fresh determination of the degree of magnification.

Polarisation.—The apparatus consists of a polariser, or Nicol prism, fitting below the microscope stage (Fig. 37) and a similar prism forming the analyser fitting above the objective. As in the case of the polarimeter, with which students will be familiar, one Nicol is kept stationary whilst the other is rotated.* For botanical work the analyser is usually fitted, when required, either between the objective and nosepiece (Fig. 38) or over the eyepiece (Fig. 39). In geological work polarised light is so frequently used that the apparatus is permanently fitted, the analyser being placed in the body of the microscope.

* The theory and use of the polarimeter is described in Bentley and Driver's *Textbook of Pharmaceutical Chemistry*, p. 17.

Many crystalline substances show brilliant colours when examined in polarised light, *e.g.* asbestos, sucrose, cinnamic acid. Starch grains often show a black cross, a phenomenon due to the crystalline refraction of the material. Polarised light is useful for the detection of calcium oxalate, especially when only small quantities are present in the tissues under examination. It appears bright on a black background.

As mentioned on p. 94, calcium oxalate crystals may belong to either the tetragonal or monoclinic systems. In botanical literature, however, the crystals are usually described as prisms, rosettes, etc., without reference to their crystal system. The determination of the crystal system involves the use of a geological microscope fitted with a graduated rotating stage and polarising apparatus. The crystal is placed with its axis parallel to the longer diagonal of the polarising Nicol. If the crystal belongs to the tetragonal system the polarised light passes unchanged and on reaching the analyser is completely absorbed, the field appearing dark, *i.e.* extinction takes place. Monoclinic crystals, on the other hand, only show extinction when the vertical axis makes an angle with the diagonal of the Nicol known as the extinction angle. As the crystal is rotated through 360° it becomes invisible, *i.e.* shows extinction, four times.*

* For further details books on the microscopical study of minerals should be consulted.

Reagents

Directions for making the following reagents, if not given below, will be found in the appendices of the *B.P.* or *B.P.C.* Some of the uses of each are mentioned, but further details will be found elsewhere, particularly in the remaining sections of this part.

Acetic Acid, B.P.—Used to distinguish between calcium carbonate and calcium oxalate.

Alcohol.—Different strengths are used for preserving material and for hardening. Alcohol acts as a clearing agent by dissolving oils, resins, chlorophyll, etc. It does not dissolve gums and mucilages, and is therefore a useful mountant for drugs containing them.

Alkanna Tincture, B.P.—Stains oils and fats and suberised and cuticularised walls.

Chloral Hydrate Solution, B.P.C.—A valuable and widely used clearing agent. Dissolves many cell contents, particularly on warming; expands shrunken cell walls. Particularly useful when examining for calcium oxalate.

Chloral Hydrate and Glycerin, B.P.C., combines the properties of chloral hydrate and glycerin and is therefore useful for slow clearing without heat. Preparations mounted in it may be left for some days without undue evaporation.

Chloral Hydrate with Iodine, Solution of, B.P.—When used cold causes shrunken cells and starch grains to expand. The iodine stains starch or hemicelluloses.

Chlorinated Soda, Solution of, B.P.—See Clearing and Bleaching (p. 113). Prolonged action of the reagent causes delignification and removal of starch.

Chloroform.—A defatting agent.

Chromic Acid Solution, B.P.C.—See Disintegration and Isolation of Tissues.

Chromic and Nitric Acids Solution, B.P.C.—See Disintegration and Isolation of Tissues.

Clove Oil.—A useful clearing agent for powders containing much oil.

Cresol.—A suitable mountant for chalks, kieselguhr, etc.

Chlor-zinc-iodine Solution, B.P.C. (syn. Schulze's Solution).—Used as test for walls containing celluloses. Iodine solution followed by sulphuric acid gives similar results.

Copper Oxide, Ammoniacal Solution of, B.P.—This solution must be freshly prepared. It causes swelling and solution of

cellulose walls. The balloon-like swellings produced in raw cotton are best observed if the reagent be diluted with an equal volume of distilled water. This solution is commonly known as cuoxam.

Corallin, Alkaline Solution of, B.P. (syn. Corallin-Soda).—Stains the callose of sieve-plates and some gums and mucilages.

Ether-Alcohol, B.P.C.—A defatting agent.

Ferric Chloride, Test Solution of, B.P.—See Tannins.

Glycerin, Dilute.—One volume of glycerin is mixed with two volumes of distilled water. A useful mountant for preparations which may be left for some time, as it does not dry up. It has some clearing action, but is much inferior in this respect to chloral hydrate. It is not a good mountant for starch, as the grains tend to become transparent and striations, etc., are difficult to see; water is preferable.

Hydrochloric Acid.—This is used in testing silk, preparations containing colchicine, and with phloroglucinol as a test for lignin.

Iodine Water, B.P.C.—This gives a blue colour with starch and hemicelluloses. Iodine followed by sulphuric acid resembles chlor-zinc-iodine (*q.v.*).

Lactophenol Solution, B.P.C.—See Clearing.

Mercury Nitrate, Solution of, B.P. (syn. Millon's Reagent).—See aleurone grains, wool, and silk.

Nitric Acid 10 per Cent.—See crude fibre.

Phloroglucinol, Solution of, B.P.—Used with hydrochloric acid as a test for lignin.

Picric Acid Solution.—A saturated solution in water which is used to stain aleurone grains and animal fibres.

Potash Solution.—A 5 per cent. solution is commonly used for clearing and disintegrating (*q.v.*) and for the separation of cotton from wool. A 50 per cent. solution is used in testing for chitin in ergot and for eugenol in clove. A $2\frac{1}{2}$ per cent. solution is used for preparing crude fibre (*q.v.*).

Potassio-Cupric Tartrate, Solution of, B.P. (syn. Fehling's Solution).—Used in testing for reducing sugars such as glucose.

Potassio-Mercuric Iodide, Solution of, B.P. (syn. Mayer's Reagent).—A precipitant for most alkaloids.

Potassium Chlorate and Nitric Acid.—Produces bleaching, disintegration, and delignification.

Ruthenium Red, Solution of, B.P.—Stains many gums and mucilages.

Sodium Carbonate Solution, B.P.C.—This is useful for the disintegration of fibres such as flax, where the use of an oxidising agent is not required.

Sudan III Solution, B.P.C.—This stains oils and suberised walls, and is useful in the examination of secretory cells and ducts, the walls of which are often suberised.

Sulphovanadic Acid Solution, B.P.C.—Used as test for strychnine.

Sulphuric Acid 80 per Cent.—Concentrated sulphuric acid causes rapid charring, but dilutions containing 80 per cent. or less form useful reagents. The behaviour of cotton, wool, chinks, calcium oxalate, and sections of strophanthus seeds should be noted. The acid dissolves cellulose and lignified walls, but has little action on suberin.

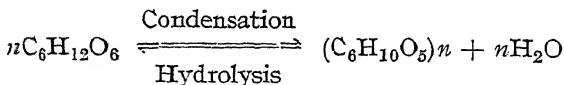
Water, Distilled.—A useful mountant for the examination of starches. Sections which have been bleached with solution of chlorinated soda or similar reagent may be freed from the bubbles of gas which they frequently contain by placing them in freshly boiled distilled water.

CHAPTER IX

STARCHES, EPIDERMAL TRICHOMES, AND CALCIUM OXALATE; POWDERED DRUGS

Starches

Distribution and Formation.—Starch occurs in granules of varying size in almost all organs of plants. Of particular pharmaceutical interest are the starches of maize and rice, which constitute the starch of the British Pharmacopœia; and potato starch, which is used for the preparation of soluble starch, a reagent used in the Pharmacopœia. Starch is found most abundantly in roots, rhizomes, fruits, and seeds, where it usually occurs in larger grains than are to be found in the chlorophyll-containing tissues of the same plant. The small grains of starch formed in many leaves and stems by the condensation of sugars are afterwards hydrolysed into sugars so that they may pass in solution to storage organs where, under the influence of leucoplasts, large grains of reserve starch are formed. The simplest method of expressing these changes is as follows :—



In certain families and genera starch is not formed but other carbohydrate reserves may be built up, *e.g.* inulin in the Compositæ. In other cases the carbohydrates produced are converted into fixed oils and fats. For example, linseed, which contains starch whilst developing, contains only oil and protein as food reserves when ripe.

The following starch-containing plants may be mentioned :—

Family	Plant	Economic Product
Cycadaceæ.	<i>Zamia floridana.</i>	Florida arrowroot.
Gramineæ.	<i>Zea Mays.</i>	Maize or corn.
	<i>Oryza sativa.</i>	Rice.
	<i>Triticum sativum.</i>	Wheat.
	<i>Avena sativa.</i>	Oats.
	<i>Hordeum</i> species.	Barley.
	<i>Secale cereale.</i>	Rye.
Palmae.	<i>Metroxylon Rumphii.</i>	Sago.
Musaceæ.	<i>Musa</i> species.	Bananas and plantains.

Family	Plant	Economic Product
Zingiberaceæ.	<i>Zingiber officinale</i> .	Ginger.
	<i>Curcuma</i> species.	East Indian arrowroot and turmeric.
Marantaceæ.	<i>Maranta arundinacea</i> .	West Indian arrowroot.
Cannaceæ.	<i>Canna edulis</i> .	Queensland arrowroot or tous les mois.
Polygonaceæ.	<i>Polygonum Fagopyrum</i> .	Buckwheat.
Euphorbiaceæ.	<i>Manihot utilisima</i> .	Manihot starch and tapioca.
Legumi	<i>Phaseolus vulgaris</i> .	Bean flour.
	<i>Ervum Lens</i> .	Lentil flour.
	<i>Pisum sativum</i> .	Pea flour.
Convolvulaceæ.	<i>Ipomœa Batatas</i> .	Sweet potato.
Solanaceæ.	<i>Solanum tuberosum</i> .	Potato.

Chemical Nature of Starches.—Commercial starches, the preparation of which is described below, are not chemically pure. Typical analyses * are as follows :—

	Maize.	Rice.	Potato.
Starch.. ..	84.14 per cent.	85.18 per cent.	79.64 per cent.
Water	13.95 " "	13.70 " "	19.22 " "
Nitrogenous Matter	1.53 " "	0.88 " "	0.69 " "
Ash	0.38 " "	0.30 " "	0.33 " "

Starch grains consist of more than one chemical compound, since it has long been known that although they are normally insoluble in cold water long grinding with sand will produce a solution which gives a blue colour with iodine. The grain is found to consist of an outer insoluble portion known as *amylopectin* and an inner soluble portion called *amylose*.

Under suitable conditions, boiling water and certain acids, enzymes, and solvents rupture, decompose, or dissolve the amylopectin, allowing solution of the amylose to take place. Amylopectin is responsible for the high viscosity of starch paste, whereas a solution of amylose is non-viscous.

The analyses of Taylor and Iddles † indicate that potato starch contains less amylopectin than maize or rice. It thus seems well suited for the preparation of soluble starch and dextrins. Their figures are :—

	Amylose (β-amylose)	Amylopectin (α-amylose)
Maize and rice	81-88 per cent.	12-19 per cent.
Potato	97-98 " "	1.8-2.9 " "

Hydrolysis of Starch.—By hydrolysing starch under suitable conditions one prepares commercial dextrins, maltose, commercial liquid glucose, and pure glucose or dextrose.

(a) *Action of Enzymes.*—Malt extract has little action on

* Thoms, Handbuch der Pharmazie, Band V.

† Taylor and Iddles *Applied Chemistry Reports*, 1926, 499.

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whole starch grains, but hydrolyses the amylose fraction of starch paste or a solution of soluble starch as follows :—

Soluble starch or
polymerised amylose \rightarrow Erythrodextrin \rightarrow Achroodextrin \rightarrow Maltose.

Erythrodextrin is identical with animal starch or glycogen. It gives a reddish-brown colour with iodine, whereas achroodextrin and maltose give no colour. Further hydrolysis of the maltose to glucose can be brought about by the enzyme maltase contained in yeast.

(b) *Action of Acids*.—As mentioned above, the first action of acids is to form “soluble” starch. Hydrolysis then proceeds with the formation of dextrins, maltose, and finally glucose.

Soluble Starch is prepared by treating commercial potato starch with hydrochloric acid until, after washing, it forms a limpid, almost clear solution in hot water. A soluble starch solution should show little reduction with Fehling's and give a deep blue colour with iodine.

Commercial Dextrins.—High-grade dextrins, such as the dextrin of the *B.P.C.*, are prepared by heating starch, which has been moistened with a small quantity of dilute nitric acid and dried, at 110° to 115° . The product is known as white dextrin. Inferior dextrins which have a yellow or brown colour are prepared by roasting starch at 150° to 250° without the addition of acid.

White dextrins may contain up to 15 per cent. of soluble starch, the remainder consisting largely of erythrodextrin. Yellow dextrins are more completely hydrolysed and, unlike the white variety, contain appreciable quantities of maltose, which may be detected and estimated by means of Fehling's solution.

As dextrins are soluble in water they should be examined microscopically in alcohol, when the variety of starch used, usually potato or maize, may be ascertained. Soluble starch and dextrins usually show a well-marked cross when examined in polarised light. When irrigated with iodine solution any grains consisting of soluble starch stain blue, whilst those which have been dextrinised are coloured violet or reddish violet. If iodine is added to aqueous solutions of soluble starch, white dextrin, and yellow dextrin the colours obtained are blue, bluish-violet, and dull reddish-violet respectively.

Preparation of Starches.—Many patented processes are in use for particular starches and the procedure adopted depends on the degree of purity desired and the nature of the compounds from which the starch has to be freed. Cereal starches,

for example, have to be freed from cell débris, oil, soluble protein matter, and the abundant insoluble proteins (glutelins and prolamins) known as "gluten." Potato starch, on the other hand, is associated with vegetable tissue, mineral salts, and soluble proteins.

Wheat and similar starches were at one time prepared by kneading the ground material in a stream of water, the gluten remaining as a sticky mass whilst the starch separated on standing from the milky washings. The following method is, however, more satisfactory.

*Preparation of Maize and Rice Starches.**—The grain is first softened by soaking at 50° for about two days in a 0.2 per cent. solution of sulphurous acid. This assists disintegration and prevents putrefaction. The fruits are then disintegrated by mills which tear them without breaking the oil-containing embryo or "germ." The germs are floated and skimmed off from a suspension in water and used for the preparation of germ oils, which are an important source of vitamins. Maize germ oil is official in the U.S.P. XI under the name "Oleum Maydis." The remainder of the grain is ground wet until over 95 per cent. passes, in the form of a 40 per cent. paste, a fine silk sieve; the remainder, consisting of cell débris and some gluten, is retained by the sieve. After further dilution, the remaining gluten may be removed as follows: the suspension is allowed to flow through shallow troughs about 120 ft. long and 2 ft. wide, when the starch, being heavier than the gluten, deposits first. This "tabling" operation is repeated several times, or the remaining gluten may be removed by treating the starch with dilute alkali. Gluten dissolves or swells in alkali and is separated from the starch by means of a No. 200 sieve, which allows the starch to pass through. The starch is thoroughly washed in a filter press, dried at a moderate temperature, and powdered.

Preparation of Potato Starch.—The potatoes are washed and reduced to a fine pulp in a rasping machine.† Much of the cell débris is removed by washing the pulp in an inclined trough having a wire gauze bottom. The milky liquid which passes through the sieve contains starch, soluble proteins and salts, and some cell débris. On standing the starch separates more rapidly than the other insoluble matter, and may thus be purified by processes resembling the "tabling" described

* For further details see Read's *Industrial Chemistry and Applied Chemistry Reports*, 1920 and 1926.

† For plans of machines and starch factory, see Trotman and Thorp, *Bleaching and Finishing of Cotton*.

above. The amount of protein matter in potato is only about 1.9 per cent., whereas maize and rice contain about 9.0 and 7.5 per cent. respectively. As the proteins of potato are of different nature from those of the cereals, being water-soluble, no treatment with alkali is required. The washed starch is collected, dried, and powdered.

Macroscopical Characters.—Starch occurs in irregular, angular masses or as a white powder. It is insoluble in cold water but forms a colloidal solution on boiling with about fifteen times its weight of water, the solution forming a translucent jelly on cooling. A starch mucilage is coloured deep blue with solution of iodine, the colour disappearing on heating

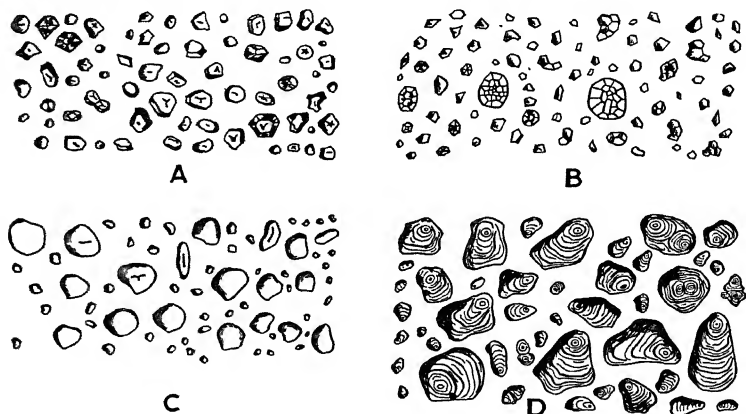


FIG. 40.—Starches. A, maize; B, rice; C, wheat; D, potato. All 200 : 1. (After Tschirch.)

to 93° but reappearing on cooling. Maize starch grains begin to swell in water at 50°, become pasty at 55°, and completely lose their form at about 62°. Other starches show these changes at different temperatures.

Maize starch is neutral, but other commercial starches frequently show an acid or alkaline reaction to litmus or other indicators. The test may be conveniently made as follows : Shake about 0.2 G. of the starch with 5 ml. of distilled water and 2 drops of B.D.H. universal indicator. The latter is a mixture of indicators which gives different colours according to the pH of the solution to which it is added. A table indicating the pH corresponding to each colour is given on the label. Maize

starch when so tested is almost exactly neutral, rice is definitely alkaline, whilst wheat and potato may be acid.

Microscopical Characters.—Starches are best identified by means of the microscope. Some of the more important microscopic characters of maize, wheat, rice, and potato starches are set out below. Tables in which many other starches are dealt with in a similar manner are given by Wallis * and by Moeller and Griebel.†

Variety.	Form.	Size in μ .			Hilum and Striations.
		Small.	Medium.	Large.	
Maize	Grains from the outer horny endosperm mulier-shaped.	10	15 to 25	30	Hilum a central triangular or 2- to 5-stellate cleft. No striations.
	Grains from the inner mealy endosperm polyhedral or sub-spherical. In the commercial starch all the grains are simple.	2	10 to 30	35	
Wheat	Larger grains lenticular, smaller ones globular. A few compound grains with 2 to 4 components, which, if separated, are polyhedral.	2 to 9	30 to 40	45	Hilum a central point, seldom cleft. Concentric but rather faint striations.
Rice	Compound grains with an angular outline and from 2 to about 150 components. Component grains polyhedral, with sharp angles.	2	4 to 6	10	Hilum a central point. No striations.
Potato	Mostly simple grains, hatchet-, wedge-, or mussel-shaped. A few compound grains of 2 or 3 components firmly fused together.	2	45 to 65	110	Hilum in the form of a point; eccentric about $\frac{3}{4}$ to $\frac{1}{4}$. Concentric striations well marked, some rings, however, more distinct than others.

Epidermal Trichomes and Calcium Oxalate

The diagnostic importance of epidermal trichomes and calcium oxalate lies in the fact, that, although very common, both show great variation in form and size. Their microscopical examination presents little difficulty and forms a good introduction to the microscopy of drugs.

* Wallis, P.J., 1933, Sept. 30, 396.

† Moeller and Griebel (after A. Scholl), *Mikroskopie der Nahrungs- und Genussmittel aus dem Pflanzenreiche*, pp. 45 to 47.

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Epidermal Trichomes

The epidermis of leaves and flowers may often be examined without cutting sections. The dry material is exposed to a moist atmosphere or soaked in water and a piece of epidermis removed. In the case of many leaves this is readily done by turning it over a finger, making a small slit in the epidermis with a razor and tearing off a portion of epidermis with the fingers or pair of forceps. This may be mounted in dilute

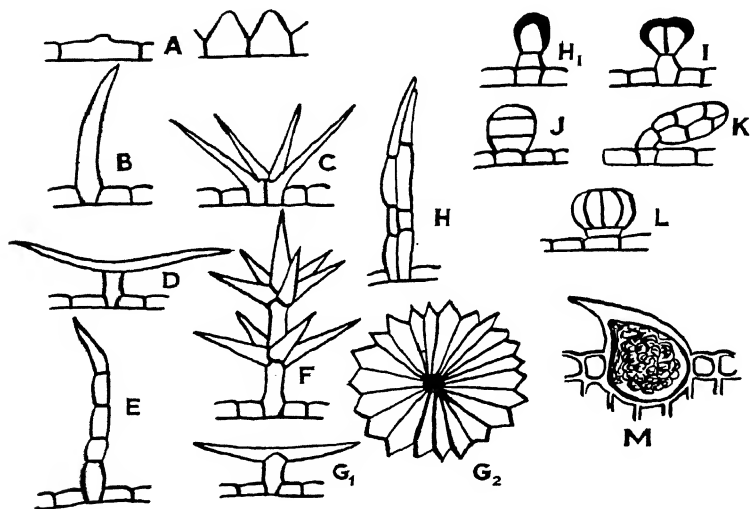


FIG. 41.—Types of hairs. A, papillæ; B, unicellular hair; C, group of unicellular hairs; D, T-shaped hair; E, uniseriate hair; F, multicellular branched hair; G₁ and G₂, scale hair from side and from above; H, biseriate hair; H₁ to L, types of glandular hairs; M, unicellular, cystolith-containing hair of *Cannabis sativa*. (After Thoms' *Handbuch der Pharmazie*.)

glycerin or solution of chloral hydrate and examined. Thin leaves, petals, wormseed, etc., may be mounted whole and cleared by boiling gently with solution of chloral hydrate for a few minutes. In such cases not only may the epidermis be examined but by focusing downwards sub-epidermal structures such as calcium oxalate crystals, volatile oil cells, and stone cells may be seen. Thick leaves and those which are strongly cuticularised may be heated in a water-bath for about 30

minutes with dilute potash solution. After washing, the fragments are mounted and, by gentle pressure and sliding of the cover-slip, the epidermis may be separated from the underlying tissues.

In the case of fruits and seeds the epidermis may be difficult to remove and thin surface sections must be cut with a razor and cleared. Alternatively, disintegration methods may be employed. For example, the lignified hairs of *nux vomica* may be separated by macerating pieces of testa in a mixture of nitric and chromic acids. See Disintegration, p. 114.

Most leaves and many herbaceous stems, flowers, fruits, and seeds possess hairs or trichomes of one kind or another. Many show hairs of more than one type. Hairs may be grouped into non-glandular or clothing hairs and glandular hairs. In both classes unicellular and multicellular hairs are found. Some examples of the different types of hair met with are shown in Fig. 41. A particular type of hair is often characteristic of a plant family or genus, *e.g.* biserial hairs of the form shown at H are common in the Compositæ, while glandular hairs such as K and L are found in the Solanaceæ and Labiatae respectively. If

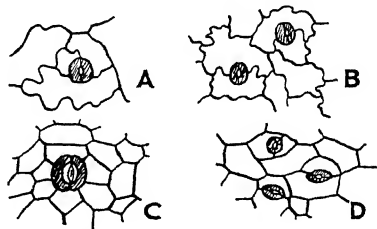


FIG. 42.—Types of stomatal arrangement. A, *Atropa Belladonna*; B, typical labiate; C, *Arctostaphylos Uva-ursi*; D, *Cassia angustifolia*. (After Thoms' *Handbuch der Pharmazie*.)

the glandular hairs of peppermint are examined it will be noted that the cuticle is raised by a secretion of oil in which crystals of menthol may be seen. For types of hair found on seeds see cotton (Fig. 48), *strophanthus* seeds (Fig. 192), and *nux vomica* seeds (Fig. 188).

The epidermal trichomes having been examined, other epidermal structures of diagnostic importance may be noted. Stomata, for example, are most commonly found on aerial leaves, but do occur in other positions, *e.g.* on bulbs, corms, herbaceous stems, and fruits. In some leaves stomata are entirely absent from one surface, while in other leaves they are equally numerous on both surfaces. Any characters such as sunken stomata or the presence of an abnormally or locally thickened cuticle should also be noted. For example, the

striated cuticle of belladonna and the locally thickened cuticle of coca leaves are important diagnostic characters of these leaves. Of great diagnostic importance are the number, relative size, and position of the epidermal cells surrounding the stomata. Characteristic types found in the Solanaceæ, Labiataë, Ericaceæ, and Leguminosæ, are shown in Fig. 42.

Calcium Oxalate

Calcium oxalate is a dimorphous salt and both types of crystal occur in plants. They belong either to the tetragonal

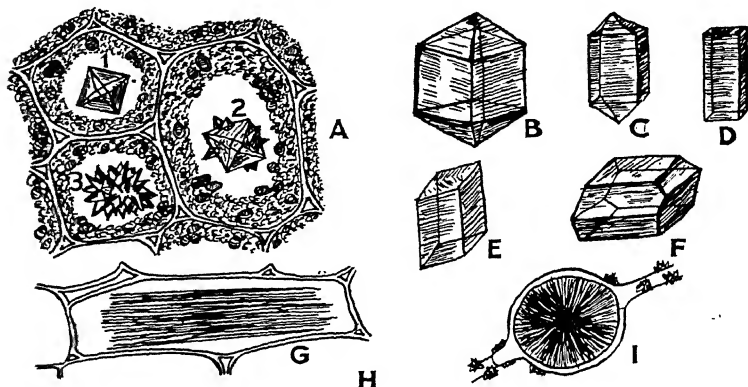


FIG. 43.—Calcium oxalate. A-D, crystals of the tetragonal system; E-I, crystals of the monoclinic system; A3, a rosette crystal formed of tetragonal crystals as seen in A1 and A2; D, a tetragonal prism; E, a monoclinic prism; G, raphides; H, a single needle crystal; I, a sphaerocrystal. (After Thoms' *Handbuch der Pharmazie*.)

or monoclinic systems. Calcium oxalate crystals of these two systems differ in the amount of water they contain and in optical properties. In the tetragonal system the crystals have forms such as are shown in Fig. 43, A-D. These have the formula $\text{CaC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$ and are formed owing to supersaturation of the sap with calcium oxalate. In the monoclinic system the crystals have forms such as are shown in Fig. 43, E-I, have the formula $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$, and result from an excess of oxalic acid. The monoclinic crystals shine more brightly in polarised light than do those of the tetragonal system. In addition to the forms illustrated above very minute crystals, known as

sandy crystals or micro-crystals, are found in the Solanaceæ and other families. They appear to belong to the tetragonal system. Numerous examples of the diagnostic use of calcium oxalate will be given later, but the following may be mentioned here. The solanaceous leaves may be distinguished from one another, belladonna by its sandy crystals, stramonium by its cluster crystals, and henbane by its single and twin prisms. Similarly, phytolacca leaves and roots, which both possess acicular crystals, are distinguished from belladonna leaves and roots which have sandy crystals. Single needle crystals occur in ipecacuanha (Fig. 210), bundles of raphides in many monocotyledons, *e.g.* squill (Fig. 75), and rosette crystals in rhubarb (Fig. 100). The type of cell in which the crystals occur is often of diagnostic importance, *e.g.* cascara bark has rows of crystal-containing parenchymatous cells abutting on the fibres, and calumba contains calcium oxalate in the sclerenchymatous cells.

A Scheme for the Examination of Powdered Drugs

The following scheme is intended to show how the presence or absence of starch, epidermal trichomes, and calcium oxalate may be used for the identification of important vegetable drugs.*

Preliminary Tests

1. Note the colour. *White*: acacia, tragacanth; *light yellow*: colocynth, peeled liquorice, ginger, quassia, squill; *light brown*: ipecacuanha, unpeeled liquorice, nux vomica, fennel, gentian, cascara, coriander, cardamoms, jalap, linseed,† aloes †; *cinnamon brown*: cinnamon, catechu; *dark brown*: clove, Curacao aloes †; *dark reddish-brown*: nutmegs; *violet*: ergot; *red*: cinchona; *orange*: rhubarb; *pale green*: lobelia; *green*: henbane, belladonna, stramonium, senna, digitalis.

2. Note odour. The following are particularly characterised: ginger, fennel, gentian, coriander, cardamoms, cinnamon, clove, nutmegs.

3. Note taste. The following are particularly characterised: *aromatic*: coriander, cardamoms, cinnamon, clove, nutmegs; *aromatic and pungent*: ginger; *bitter*: colocynth,

* All for which detailed microscopical study is laid down in the Ph.C. & B.Pharm. syllabuses are included.

† Aloes vary considerably in colour; linseed is difficult to powder finely and shows a mixture of light and dark-coloured particles.

quassia, nux vomica, gentian, aloes, squill, cinchona ; *sweet* : liquorice ; *astringent* : catechu.

4. Mix a small quantity of the powder with a few drops of water and allow to stand. Aqueous extracts and inspissated juices such as catechu and aloes dissolve almost completely, whilst the gummy or mucilaginous nature of drugs such as acacia, tragacanth, and linseed becomes apparent.

5. Shake a little powder in half a test-tube full of water and if any marked frothing occurs suspect saponin-containing drugs, such as clove and nutmegs ; boil gently and note the odour of any volatile oil evolved. Filter and divide into two portions, which may be tested for tannins and for anthraquinone derivatives as follows :—

(a) Test for tannin, using iron complex or phenazone (see Chapter XXIV). *Tannins are absent* from quassia, squill, strophanthus, capsicum, and ginger ; *gallitannins are present* in cloves and rhubarb ; *phlobatannins are present* in catechu, krameria, prunus serotina, cinnamon, and cinchona.

(b) Test for anthraquinones by shaking the aqueous extractive with ether, separating and adding to the ethereal solution about one-third of its volume of ammonia. A pink colour is obtained with rhubarb, cascara, and senna and with some samples of aloes.

Microscopical Examination

If the preliminary tests have shown that the drug dissolves or becomes mucilaginous in water, trial should be made with other liquids such as alcohol, olive oil, or lactophenol until one is found in which the drug is insoluble. In most cases, however, the following procedure may be adopted :—

Examination for Starch.—Mount in water, examine, and sketch any granules observed and prove whether they are starch or not by irrigation with iodine water.

Examination for Epidermal Trichomes and Calcium Oxalate.—Mount in chloral hydrate, boil gently until clear, and examine. To ensure that calcium oxalate, if present in small quantity, is not overlooked, polarised light may be used.

Examination for Lignin.—Moisten the powder with an alcoholic solution of phloroglucinol and allow to stand until nearly dry ; add concentrated hydrochloric acid, apply a cover-glass, and examine. Note the presence or absence of lignified vessels, fibres, parenchyma, sclereids, or hairs (*e.g.* nux

vomica). If vessels or fibres do not stain pink suspect rhubarb or ginger.

A considerable amount of information should have been derived from the preliminary tests and the above three mounts and the examination may be continued on the lines indicated in Chapter X to determine as far as possible the arrangement of the tissues, the markings of the cell walls, and the chemical nature of the walls and cell contents. It is often advisable to defat oily powders, to bleach highly coloured ones, and to prepare a crude fibre of those containing much starch.

The identity of a powder should not be regarded as established until it has been compared with one of known authenticity. Microscopical measurements of cells and cell contents should be made whenever possible and compared with those published in the literature.

The following tables, based on the presence or absence of starch, epidermal trichomes, and calcium oxalate, may be found useful. Although only designed to include a limited number of important drugs, they may easily be extended to include a larger number by the student or teacher.

TABLE 1

Absent: Starch, Epidermal Trichomes, and Calcium Oxalate

<i>Drug.</i>	<i>Characteristics.</i>
Aloe.	<p><i>Present.</i>—Splinters mounted in olive oil show yellowish-brown amorphous masses (vitreous aloes) or similar masses containing minute crystals of aloin (hepatic aloes). Almost entirely soluble in water. Confirm by chemical tests.</p> <p><i>Absent.</i>—Vegetable tissues, except when derived from the Zanzibar variety, which may contain leaf fragments.</p>
Acacia.	<p><i>Present.</i>—When mounted in alcohol and irrigated with water the sharp edges of the particles rapidly become rounded and solution takes place. Confirm by chemical tests.</p> <p><i>Absent.</i>—Vegetable tissues.</p>
Colocynthis.	<p><i>Present.</i>—Abundant thin-walled, slightly lignified, parenchymatous cells with oval pitted areas; few spiral and annular vessels.</p> <p><i>Absent.</i>—Sclereids, fixed oil, and aleurone (except in such amounts as are allowed by the official limits for seeds and outer rind); large vessels, cork, and fibres.</p>

- | <i>Drug.</i> | <i>Characteristics.</i> |
|----------------|---|
| Ergota. | <i>Present.</i> —Pseudoparenchyma with highly refractive walls; purplish-brown rectangular cells; fixed oil and protein. Confirm by test for chitin (p. 119) and by fishy odour on boiling with potash.
<i>Absent.</i> —Lignified tissues. |
| Linum. | <i>Present.</i> —Isodiametric epidermal cells with mucilaginous walls; collenchyma; lignified and pitted sclerenchymatous cells 120–190 μ long and 14–17 μ wide; polygonal pigment cells with reddish-brown contents; abundant fixed oil and aleurone grains 3–18 μ .
<i>Absent.</i> —Starch (except an occasional grain from unripe seeds); vessels and cork. |
- Note.*—The oxalate and starch in gentian are often somewhat difficult to find. If a powder appears to contain no oxalate, starch, or epidermal trichomes the possibility of it being gentian (Table 6) should be considered.

Space for sketches or notes on other drugs, such as senega :—

POWDERED DRUGS

TABLE 2

Present : Calcium Oxalate

Absent : Starch and Epidermal Trichomes

<i>Drug.</i>	<i>Calcium Oxalate.</i>	<i>Other Characteristics.</i>
Caryophyllum.	Rosettes 6-20 μ .	<p><i>Present.</i>—Large schizo-lysi- genous oil glands; pollen grains triangular in outline, 15-20μ; fibrous layer from the anther walls; epidermis with thick cuticle and large stomata; pericyclic fibres up to 650μ; small spiral and annular vessels.</p> <p><i>Absent.</i>—Pitted sclerenchy- matous cells above 70μ in diameter, prisms of oxalate, and vessels with reticulate thickening (except in such amounts as are allowed by the official limit for stalks); starch; cork.</p>
Coriandrum.	Rosettes 3-10 μ in the aleurone grains. Prisms in the stomata- bearing epicarp, which is, however, often thrown off.	<p><i>Present.</i>—Endosperm con- taining fixed oil and aleurone; sinuous rows of fusiform sclerenchymatous cells; frag- ments of light yellow vittæ; large thin-walled hexagonal sclerenchymatous cells and groups of thin-walled cells showing a parquetry arrange- ment.</p> <p><i>Absent.</i>—Starch, trichomes, reticulate lignified parenchy- ma, large vessels, cork.</p>
Fœniculum.	Rosettes 2-5 μ in the aleurone grains.	<p><i>Present.</i>—Endosperm con- taining fixed oil and aleurone; lignified reticulate parenchy- ma of mesocarp; brown vittæ up to 200μ in width; endo- carp of elongated thin-walled parquetry cells arranged in parallel groups of 5 to 7 and often adhering to the cells of the mesocarp and testa; epidermis with smooth cuticle and occasional stomata.</p> <p><i>Absent.</i>—Starch, trichomes, fusiform sclerenchyma, large vessels, cork.</p>

<i>Drug.</i>	<i>Calcium Oxalate.</i>	<i>Other Characteristics.</i>
Scilla.	Numerous bundles of acicular raphides 50-900 μ long and 5-8 μ wide.	<i>Present.</i> —Small lignified spiral and annular vessels ; mucilage surrounding the oxalate crystals stains with corallin soda. Occasional fragments of cuticularised epidermis with few stomata ; very few small starch grains ; reducing sugar. <i>Absent.</i> —Fixed oil, aleurone and fragments of reddish scales (red squill).

Space for sketches or notes on other drugs, such as orange-peel and lemon-peel :—

TABLE 3

Present : Epidermal Trichomes

Absent : Starch and Calcium Oxalate

<i>Drug.</i>	<i>Epidermal Trichomes.</i>	<i>Other Characteristics.</i>
Nux Vomica.	Trichomes of clothing type, closely arranged and lignified. Upper portion cylindrical, about 100μ long, many lignified ribs readily splitting into rod-like fragments. Base thick-walled with slit-like pits and small branched cavities; wavy polygonal outline in surface view.	<i>Present.</i> —Endosperm cells with thick walls, composed of mannans and galactans, containing an oily plasma and a few aleurone grains about $10-30\mu$; well-marked protoplasmic strands (plasmodesma) passing from cell to cell. Presence of brucine shown by means of nitric acid, and of strychnine with ammonium vanadate and sulphuric acid. <i>Absent.</i> —Starch, calcium, oxalate, vessels, fibres.
Digitalis Folium.	Trichomes of clothing and glandular types :— 1. Simple, bluntly pointed uniseriate hairs of 2 to 7 cells. Walls finely warty and in some of the cells collapsed. 2. Glandular hairs with unicellular or, more rarely, uniseriate pedicel bearing a unicellular or bicellular gland.	<i>Present.</i> —Upper epidermis with slightly wavy anticlinal walls and few stomata; lower epidermis with wavy anticlinal walls and numerous Ranunculaceous stomata; marginal teeth with water pores; small spiral, annular, and reticulate vessels; palisade and spongy parenchyma with chloroplasts. <i>Absent.</i> —Starch, oxalate, fibres.
Catechu.*	Simple, unicellular trichomes up to about 350μ in length. The wall is smooth, moderately thick and lignified. These trichomes are particularly numerous on the stipules.	<i>Present.</i> —Abundant interlacing acicular crystals of catechin. These may be dissolved by means of alcohol and the vegetable debris which remains examined. It includes lignified pericyclic fibres, wood fibres, and spiral, annular, and pitted vessels from the stems. Leaf fragments, some bearing trichomes.

* The following notes are based on the examination of samples of Johore and Dutch cube catechus and of the leaves and twigs of *Uncaria gambier*. sent to us by the courtesy of Mr. T. Roebuck, Ph.C., of Singapore.

<i>Drug.</i>	<i>Epidermal Trichomes.</i>	<i>Other Characteristics.</i>
Catechu — <i>contd.</i>		<i>Absent.</i> —Starch is strictly limited by the B.P. description to "not more than an occasional starch grain." †

† In the Dutch East Indies cube gambier is made (a) for export to Europe, (b) for use in the East. In the latter case a certain proportion of roasted or fresh rice husks is regularly added. This helps the cubes, whilst soft, to keep their form and makes them more porous. We have personally observed rice husks and starch in some samples of catechu sold in this country.

Space for sketches or notes on other drugs, such as saffron :—

TABLE 4

Present : Starch

Absent : Calcium Oxalate and Epidermal Trichomes

<i>Drug.</i>	<i>Starch.</i>	<i>Other Characteristics.</i>
Tragacantha.	Starch grains up to 50 or more in a cell; some simple, rounded, or ellipsoidal, and about 3 to 25 μ ; others 2-4 compound. The amount of starch varies considerably in different samples.	<i>Present.</i> —Large parenchymatous cells of pith and medullary rays; walls swelling on addition of water and showing concentric mucilaginous lamellæ; lumen often containing numerous starch grains. Iodine followed by sulphuric acid turns the primary walls blue. The mucilage does not stain with ruthenium red. <i>Absent.</i> —Calcium oxalate, epidermal trichomes.*
Myristica.	Starch grains simple or of 2 to 20 components. Individual grains 2-20 μ , mostly about 10 μ .	<i>Present.</i> —Endosperm cells containing starch; aleurone grains, one larger than the rest having a well-marked crystalloid; and abundant fat. Large reddish-brown cells of ruminant perisperm associated with large volatile oil cells and a small strand of vascular tissue; scattered brown pigment cells. Some of the outer perisperm cells contain small prisms of undetermined nature (not calcium oxalate). <i>Absent.</i> —Calcium oxalate, epidermal trichomes and sclerenchyma.
Zingiber.	Abundant, almost entirely simple, sack-shaped grains; up to 50 μ long, 30 μ wide, and 7 μ thick. Hilum in the small terminal beak. Striations faint and almost at right angles to the long axis.	<i>Present.</i> —Non-lignified spiral or reticulate vessels accompanied by elongated brown pigment cells and slightly lignified septate fibres; abundant starch-containing parenchyma; suberised secretion cells containing yellowish oleo-resin. <i>Absent.</i> —Calcium oxalate, epidermal trichomes, cork,† lignified vessels, and sclereids.

* Small quantities of epidermal trichomes, cork, and lignified elements from the stem may be found, particularly in the lower grades of tragacanth.

† Unscraped varieties of ginger have thin-walled cork cells.

Space for sketches or notes on other drugs, such as aconite, opium, and valerian :—

TABLE 5

Present : Epidermal Trichomes and Calcium Oxalate

Absent : Starch

Drug.	<i>Epidermal Trichomes and Calcium Oxalate.</i>	<i>Other Characteristics.</i>
Strophanthus	<p><i>Trichomes.</i>—Abundant simple, slightly lignified hairs up to about 800μ in length. Anticlinal walls of the base showing a lens-like lignification, whilst the much narrower upper portion has a longitudinal lignified rib.</p> <p><i>Oxalate.</i>—Occasional cluster crystals and prisms in the testa.</p>	<p><i>Present.</i>—Cells of the endosperm and cotyledons containing abundant fixed oil and <i>h</i>-strophanthin, the latter giving a green colour with 80 per cent. sulphuric acid; polygonal cells of testa, many showing circular scars of broken hairs; anticlinal walls lignified. A small amount of starch may be present.</p> <p><i>Absent.</i>—Glandular hairs, sclereids, and protein.</p>
Lobelia.	<p><i>Trichomes.</i>—Simple, unicellular, or sometimes bicellular conical hairs, up to $1,200\mu$ in length, on leaves and stems; base attached to the surrounding epidermal cells by strands of cuticle.</p> <p><i>Oxalate.</i>—Sandy and small single crystals in the mesophyll of the leaf.</p>	<p><i>Present.</i>—Stem epidermis with striated cuticle and beaded anticlinal walls; anastomosing latex vessels; pericyclic fibres; wood fibres; spiral and scalariform vessels; lignified and pitted parenchyma.</p> <p>Upper epidermal cells of leaves papillose and have beaded anticlinal walls; globules of oil in mesophyll; marginal teeth with numerous water pores.</p> <p>Pollen grains nearly spherical with 3 pores and $17-25\mu$ in diameter.</p>
Sennæ Folium.	<p><i>Trichomes.</i>—On both surfaces, unicellular, up to 260μ long, often curved near the base; thick-walled and warty, non-lignified.</p> <p><i>Oxalate.</i>—Abundant cluster crystals in the</p>	<p><i>Absent.</i>—Glandular hairs.</p> <p><i>Present.</i>—Upper and lower epidermis with numerous hairs, Rubiaceous stomata and thick cuticle; epidermal cells with straight anticlinal walls, many contain mucilage. Palisade parenchyma on both surfaces, spongy parenchyma,</p>

Drug.	<i>Epidermal Trichomes and Calcium Oxalate.</i>	<i>Other Characteristics.</i>
Sennæ Folium— <i>contd.</i>	mesophyll and rows of cells each containing a single prism about 10–20 μ surrounding the pericyclic fibres of the midrib and larger veins.	collenchyma, pericyclic fibres, small spiral and annular vessels. <i>Absent.</i> —Glandular hairs, sclereids.
Stramonium.	<i>Trichomes.</i> —Covering hairs relatively few, uniseriate, conical, 3–5-celled; basal cell the largest and usually more than 50 μ long and 35 μ in diameter at the base; wall rather thin, warty, and cuticularised. The hairs of the stem are similar, but larger, often attaining a length of 800 μ . Glandular hairs few; pedicel 1 or 2-celled, ovoid head 2–8-celled. <i>Oxalate.</i> —Cluster crystals about 10–35 μ very abundant except near the veins. Occasional prisms or twin prisms and sandy crystals near the veins.	<i>Present.</i> —Epidermal cells with straight anticlinal walls on the upper surface and wavy ones on the lower; smooth cuticle; Cruciferous stomata rare on the upper but numerous on the lower surface. Palisade and spongy parenchyma (with oxalate) and collenchyma. Spiral and annular vessels from veins; pitted vessels, wood fibres, and wood parenchyma from stems. Occasional pollen grains. <i>Absent.</i> —Lignified hairs and testa of seeds; striated cuticle.
Hyoscyamus.	<i>Trichomes.</i> —Covering hairs few, uniseriate, 1–10 (usually 2–4) celled, up to 300 μ in length. Glandular hairs numerous, up to 300 μ long; 1–4-celled, smooth pedicel and oval, slightly warty, 2–8-celled gland. <i>Oxalate.</i> —Abundant single or twin prisms and some rosette aggregates 10–25 μ in diameter; a few microsphenoidal crystals.	<i>Present.</i> —Wavy-walled epidermal cells with non-striated cuticle; Cruciferous stomata on both surfaces; veins with small vessels, but no pericyclic fibres; stems with larger vessels and lignified fibres, the latter up to 1,000 μ and sometimes forked. Pollen grains about 40 μ in diameter, nearly smooth, with 3 radiating furrows. <i>Absent.</i> —Lignified hairs; striated cuticle.

Drug.
Belladonnæ
Folium.

Epidermal Trichomes
and Calcium Oxalate.

Trichomes.—Covering hairs few, uniseriate, 2-6-celled, with thin, smooth walls.

Glandular hairs few, some resembling the clothing hairs but terminating in a unicellular gland, others having a unicellular pedicel and an oval, warty, multicellular gland.

Oxalate.—Numerous idioblasts in the mesophyll containing micro-sphenoidal crystals; occasional small prisms.

Other Characteristics.

Present.—Epidermal cells mostly with wavy walls and striated cuticle; those over the veins are rectangular; Cruciferous stomata on both surfaces; veins with small spiral and pitted vessels, but no pericyclic fibres; stem possesses slightly lignified pericyclic fibres, wood fibres, and large vessels. Pollen grains ellipsoidal, with 3 furrows; seed epidermis with convolute, thickened walls.

Absent.—Lignified hairs.

Space for sketches or notes on other drugs, such as cannabis, hamamelis, and anthemis :—

TABLE 6

Present : Calcium Oxalate and Starch

Absent : Epidermal Trichomes

Notes.—In the following table the drugs are arranged in a morphological order, namely: seed, wood, subterranean organs, and barks. Having established the presence of calcium oxalate and starch and the absence of epidermal trichomes, the powder should be examined for lignified elements, oil, and cork.

(a) On treatment with phloroglucinol and hydrochloric acid the detection of unlignified vessels indicates rhubarb; lignified vessels, quassia, liquorice, gentian, or jalap; sclereids, only cardamoms; sclereids and bast fibres, cinnamon or cascara.

(b) Oil is present in cardamoms, cinnamon, and gentian.

(c) Cork is absent from cardamoms, rhubarb, and cinnamon; present or absent in liquorice and quassia; and present in the remaining drugs in the table.

Drug.	<i>Calcium Oxalate and Starch.</i>	<i>Other Characteristics.</i>
Cardamomum.	<p><i>Oxalate.</i>—One to seven prisms $10-25\mu$ embedded in the starch of the perisperm cells.</p> <p><i>Starch.</i>—Starch aggregates filling the perisperm cells, but absent from endosperm; components $1-4\mu$.</p>	<p><i>Present.</i>—Abundant perisperm containing starch and oxalate; endosperm containing very small aleurone grains. Seed coats include elongated epidermal cells about $350\mu \times 25\mu$, a layer of large oil cells and a sclerenchymatous layer of beaker-shaped cells about 20μ wide and 40μ deep. The latter are polygonal in surface view and each has a small lumen containing a nodule of silica. A few small spiral vessels.</p> <p><i>Absent.</i>—Fibres and large vessels. Cardamom pericarps contain pitted, slightly lignified sclerenchymatous fibres.</p> <p><i>Present.</i>—All elements lignified. Vessels up to 200μ in diameter with very minute bordered pits; wood fibres surrounding vessels have moderately thick walls and oblique slit-like pits; interrupted tangential bands of wood parenchyma; medullary rays mostly 2-5 cells wide and 10-25 cells high.</p> <p><i>Absent.</i>—Sclereids and oil.</p>
Quassia.	<p><i>Oxalate.</i>—Occasional single prisms about $6-30\mu$ in files in the wood parenchyma.</p> <p><i>Starch.</i>—Grains few; mostly simple and spherical, $5-15\mu$, occasionally 2-compound.</p>	

Drug.	<i>Calcium Oxalate and Starch.</i>	<i>Other Characteristics.</i>
Rheum.	<p><i>Oxalate.</i>—Numerous cluster crystals, 20–200μ, in the parenchyma.</p> <p><i>Starch.</i>—Abundant, simple and 2–5 compound, 4–25μ; hilum usually a radiate split.</p>	<p><i>Present.</i>—Vessels, non-lignified, reticulate, up to 100μ in diameter, spiral and annular; thin-walled parenchyma containing starch or oxalate; medullary ray cells contain amorphous yellowish masses which are sparingly soluble in alcohol, but soluble in water; they give a deep red colour with caustic alkali.</p> <p><i>Absent.</i>—Sclereids, fibres, cork, and all lignified elements.</p>
Glycyrrhiza.	<p><i>Oxalate.</i>—A crystal sheath of cells, each containing a monoclinic prism 10–30μ long, surrounding the groups of bast fibres and wood fibres; a few scattered prisms in the parenchyma of the bark.</p> <p><i>Starch.</i>—Abundant, simple, oval, or rounded grains 2–20μ, mostly about 10μ; few compound grains.</p>	<p><i>Present.</i>—Lignified fibres about 15μ wide in groups of 10 to 50 in the phloem and the wood; vessels up to 200μ wide, with oval bordered pits having slit-like openings; collenchyma; sieve tissue; brownish tabular cork cells (in unpeeled drug).</p> <p><i>Absent.</i>—Sclereids, cork (in peeled drug).</p>
Jalapa.	<p><i>Oxalate.</i>—Numerous clusters 10–35μ.</p> <p><i>Starch.</i>—Often partly gelatinised; single grains ellipsoidal or ovoid, with striations and slightly excentric hilum, length 5–65μ. Compound grains with 2–6 components, often with one component up to 80μ and the remaining components much smaller.</p>	<p><i>Present.</i>—Abundant parenchyma containing starch and oxalate; vessels up to 100μ with bordered pits; brownish, thin-walled cork cells; numerous yellow secretion cells with granular contents which stain with tincture of alkanna; fibrous tracheids and a very few yellowish stone cells.</p> <p><i>Absent.</i>—Fibres.</p>
Ipecacuanha.	<p><i>Oxalate.</i>—Bundles of acicular raphides, 30–80μ long, in idioblasts throughout the parenchyma.</p>	<p><i>Present.</i>—Wood parenchyma and substitute fibres containing starch; fibres, tracheids and small tracheidal vessels (10–20μ wide) without</p>

- | | | |
|--|--|---|
| <p><i>Drug.</i></p> <p>Ipecacuanha
—<i>contd.</i></p> | <p><i>Calcium Oxalate and Starch.</i></p> <p><i>Starch.</i>—A few single grains $4-10\mu$; numerous compound grains up to 24μ consisting of 2-7 components. (N.B.—Those of <i>Cartagena</i> drug up to 35μ.)</p> | <p><i>Other Characteristics.</i></p> <p>starch. All the above are lignified. Abundant thin-walled, starch-containing parenchyma; tabular cork cells with brown contents.</p> <p><i>Absent.</i>—Large vessels, sclerenchymatous cells and phloem fibres.</p> |
| <p>Gentiana.</p> | <p><i>Oxalate.</i>—A few needles $3-8\mu$ long in some of the cells of the parenchyma. Polarised light will be found useful for their detection.</p> <p><i>Starch.</i>—A very few small grains; to detect them warm gently with chloral iodine.</p> | <p><i>Present.</i>—Abundant brown, thin-walled parenchyma containing oil globules; large reticulate or scalariform vessels; yellowish-brown, thin-walled cork often attached to the collenchymatous phelloderm.</p> <p><i>Absent.</i>—Sclerenchymatous cells and fibres.</p> |
| <p>Cinnamomum.</p> | <p><i>Oxalate.</i>—A circular crystals, $5-8\mu$ in some of the medullary ray cells.</p> <p><i>Starch.</i>—Abundant, simple, $3-10\mu$, and 2-4 compound grains.</p> | <p><i>Present.</i>—Numerous, almost colourless sclerenchymatous cells, pericyclic fibres, and bast fibres; sclerenchymatous cells up to 150μ, nearly isodiametric, often unequally thickened in a horse-shoe manner and may contain starch; phloem fibres with thick but only slightly lignified walls $300-800\mu$ long and not more than 30μ in diameter; elongated secretion cells containing volatile oil or mucilage; medullary ray cells with oxalate; traces of cork.</p> <p><i>Absent.</i>—Vessels, all but traces of cork, tabular crystals of oxalate.</p> |
| <p>Cascara
Sagrada.</p> | <p><i>Oxalate.</i>—Monoclinic prisms and clusters, usually $6-10\mu$ but occasionally up to 45μ. The prisms in a crystal-sheath surrounding the groups of stone cells and phloem fibres; the clusters scattered throughout the parenchyma.</p> <p><i>Starch.</i>—Usually</p> | <p><i>Present.</i>—Yellowish sclerenchymatous cells, with branched pits and thick, striated walls, in ovoid groups. Yellowish bast fibres up to 30 in a bundle; individual fibres $8-15\mu$ in diameter. Fragments of moss leaves, collenchyma, and thin-walled cork cells with brownish contents. The medullary rays contain a yellow substance</p> |

<i>Drug.</i>	<i>Calcium Oxalate and Starch.</i>	<i>Other Characteristics.</i>
Cascara	only a few rounded grains, up to 8μ , in the chlorophyll-containing cells.	which is coloured violet by caustic alkali.
Sagrada— contd.	<i>Oxalate.</i> —M i c r o - crystals in parenchymatous idioblasts.	<i>Absent.</i> —Vessels ; needles and sandy crystals of oxalate.
Cinchona.	<i>Starch.</i> —Simple or 2-5 compound grains, spheroidal or plano-convex, 3-15 μ in diameter.	<i>Present.</i> —Pale yellowish phloem fibres singly or in radial rows ; individual fibres up to 1,470 μ long and 20-105 μ wide ; spindle-shaped with thick pitted and striated walls and irregular lumen. Thin-walled cork, lichen fragments, latex ducts, idioblasts, and parenchyma containing amorphous reddish-brown masses or starch ; sclereids (in root bark only). An acid extract shows a blue fluorescence. <i>Absent.</i> —Vessels ; sclereids (except root bark).

Space for sketches or notes on other drugs, such as podophyllum, Indian podophyllum, calumba, prunus serotina, quillaia, krameria, and ipomea :—

CHAPTER X

TISSUES, CELL WALLS AND CELL CONTENTS

IN Chapter IX will be found an account of the microscopical examination of starches, epidermal structures, and calcium oxalate, which although often of great diagnostic importance do not usually require any elaborate treatment prior to examination. The following notes are intended for the more advanced student who is assumed to have studied this earlier work.

In Schools of Pharmacy and in examinations the time available for the microscopical examination of a drug seldom exceeds three or four hours, and the time factor is therefore an important one. Before the commencement of a practical period the student should prepare himself as far as possible by studying the drug to be examined in his textbook, or from any schedules of instructions which may be available. Arrangements must be made to ensure that a portion of the drug will be suitably prepared for section cutting. Dried drugs may be softened by exposing them to a moist atmosphere or by soaking or boiling them in water. Having cut and made a preliminary examination of one or two sections and possibly also of the powder, the student should plan his further work so as to make as complete an examination as possible, but at the same time leave sufficient time for making sketches. He must decide whether to use methods involving disintegration or bleaching, whether defatting is necessary and whether any slow-acting stains, *e.g.* tincture of alkanna, will be required. These operations should be started as soon as possible. He must also decide whether to cut any sections in the dry state for the examination of mucilage or water-soluble cell contents. Clearing agents will probably be required and he must decide which are most suitable for the drug under examination.

The following aims should be constantly kept in mind :—

(a) The determination of the size, shape, and relative positions of the different cells and tissues.

(b) The determination of the chemical nature of the cell walls.

(c) The determination of the form and chemical nature of the cell contents.

The report should state what characters appear to be of the greatest diagnostic importance, and these should be illustrated by suitable sketches. Students frequently make more preparations than they have time to examine and sketch large areas of their sections in detail, instead of making a number of diagrammatic sketches, which take little time, and detailed sketches of suitably selected areas or cells of diagnostic importance.

A. TISSUES

1. Distribution of Tissues

A general idea of the distribution of the tissues can be obtained from transverse and longitudinal sections. It is usually advisable to clear them by means of chloral hydrate or other clearing agent (see below) or stain them as follows:—

Phloroglucinol and Hydrochloric Acid.—Mount the section in the official Solution of Phloroglucinol and allow to stand for about 2 minutes; remove any alcohol which has not evaporated with a piece of filter paper; add concentrated hydrochloric acid, cover, and examine. All lignified walls (see p. 117) stain pink or red.

Hydrochloric acid is a powerful clearing agent, and it must be remembered that it will dissolve many cell contents including calcium oxalate. The vegetable débris of catechu contains phloroglucinol, and in this case the wood stains on the simple application of hydrochloric acid.

Chlor-zinc-iodide Solution.—The reagent, often somewhat slowly, stains, cellulose walls (see p. 117) blue or violet, lignified or suberised walls yellow or brown, and starch grains blue.

2. Clearing, Defatting and Bleaching

Structures are frequently obscured by the abundance of cell-contents, the presence of colouring matters, and the shrinkage or collapse of the cell walls. Reagents are therefore used for the removal of cell-contents, for bleaching, and for restoring as far as possible the original shape of the cell wall. If the microscopical examination is to be made from the section mounted in the clearing agent the refractive index of the latter is important. It may be advisable to wash the section and mount in a different medium. The commonly-used mountants glycerin, alcohol, carbolic acid, lactophenol, clove oil, and Canada balsam all have some clearing effect. The

following clearing and bleaching agents are particularly useful :—

Solution of Chloral Hydrate.—This dissolves starch, proteins, chlorophyll, resins, and volatile oils, and causes shrunken cells to expand. Chloral hydrate may be used, not only for sections, but for whole leaves, flowers, pollen grains, etc. It does not dissolve calcium oxalate, and is therefore a good reagent to use when these crystals require detection.

Solution of Potash.—Solutions of potassium hydroxide, both aqueous and alcoholic, up to a strength of 50 per cent. are used for different purposes, but for use as a clearing agent a 5 per cent. aqueous solution is most generally useful. A 0·3 per cent. solution of potash may be used for dissolving aleurone grains. A 5 per cent. solution is much more powerful, rapidly dissolving starch, protein, etc., and causing the swelling of cell walls. Potash should be washed out as soon as clearing is completed since more prolonged action is liable to cause disintegration (see below).

Ether-Alcohol.—A mixture of equal parts of ether and alcohol is useful for the removal of fixed oils, fats, resins, volatile oils, tannins, or chlorophyll. Defatting is particularly necessary in the case of oily seeds such as linseed and strophanthus. The sections may be conveniently treated in a weighing bottle.

Solution of Chlorinated Soda.—The official solution is useful for bleaching dark-coloured sections such as those of many barks and for removing chlorophyll from leaves. When bleaching is complete the sections should not be left in the reagent but should be removed and washed with water. Prolonged contact with solution of chlorinated soda causes the removal of starch and lignin which may not be desirable.

3. Disintegration and Isolation of Tissues

The use of reagents for purposes of disintegration is based on their action on the cell wall, particularly the middle lamella. Woody tissues are usually disintegrated by means of oxidising agents since these oxidise away the middle lamella, which is composed mainly of lignin. Thus dilute nitric acid has a marked disintegrating effect on wood whereas dilute sulphuric acid has not. The middle lamella of cellulose cells is composed of pectic substances which are made soluble by dilute acids or dilute alkalis, which thus effect disintegration. Pure celluloses are, however, resistant to hydrolysing and oxidising

agents, and the stability of cellulose in boiling 5 per cent. potash is made use of for the separation of cotton from wool (see below). Cellulose- α , the chief constituent of cotton wool, suffers an average loss of only 5.86 per cent. on heating at 10 atmospheres for 1 hour with 4 per cent. sodium hydroxide solution.* Cellulose- β , cellulose- γ , and other materials such as mannans, galactans, pectin, hemicelluloses, gums, lichenin, and chitin, which may occur in the cell wall, are much more readily attacked by hydrolysing agents. It will thus be seen that the composition of the "crude fibres," *i.e.* those tissues which remain after the material has been subjected to the action of hydrolysing agents under controlled conditions, is likely to vary both in amount and chemical nature in different drugs. Quantitative comparisons of the crude fibres of different samples of the same drug are, however, useful.

Potassium Chlorate and Nitric Acid.—The strength of the reagent and the time it is allowed to act must be varied according to the nature of the material. For woods, *e.g.* quassia, the material, in small pieces or thick sections, is immersed in 50 per cent. nitric acid. Small quantities of potassium chlorate are added at intervals to maintain an evolution of gas. From time to time a fragment of the wood should be removed and teased with needles. When it breaks up readily it should be washed free from acid and examined. The process should not be continued longer than is necessary since prolonged bleaching causes more or less complete destruction of the lignin.

It may be noted that *Cellulose Wadding B.P.C.* is made from wood pulp, usually pine, which is digested under pressure with sodium sulphite until the wood is completely disintegrated and delignified. The washed residue gives no pink or red colour with phloroglucinol and hydrochloric acid.

Chromic Acid and Nitric or Sulphuric Acid.—The reagent usually consists of a mixture of equal parts of 10 per cent. chromic acid and 10 per cent. nitric or sulphuric acid. It is frequently used for the disintegration of sclerenchymatous tissues such as the testas of capsicum and colocynth seeds or for the separation of lignified hairs such as those of *nux vomica* and *strophanthus*.

Solution of Potash or Soda.—As mentioned above, alkalis are used both for clearing and disintegrating. The material

* See M. M. Mehta, *Biochemical and Histological Studies on Lignification*, *biochem. J.*, 1925, II, pp. 958-997.

is usually digested with 5 per cent. potash on a water bath until the more resistant cells can be teased out of the more or less completely disintegrated parenchyma. The method is useful for the separation of the heavily cuticularised epidermis of leaves and for the isolation of secretory tissue such as the vittæ of Umbelliferous fruits and the latex vessels of lobelia. Suberised and cutinised tissues are very resistant to potash. Potash is also useful for the isolation of lignified elements such as are found in the veins of leaves, in senna stalks, and in many barks.

Separation of Cotton and Wool.—The method depends on the fact that under certain conditions wool is destroyed by treatment with sodium hydroxide whereas cotton is unaffected. About 5 G. of material, *e.g.* domette bandage, is boiled with 5 per cent. sodium hydroxide solution for about 10 minutes. The residue is then washed and examined. The procedure for making a quantitative estimation of a mixture of cotton and wool is described in the B.P.C.

Preparation of a Crude Fibre.—For qualitative work the following procedure may be adopted. Mix about 2 G. of the powdered drug with 50 mls of 10 per cent. nitric acid in a casserole. Bring to the boil and maintain at the boiling point for 30 seconds. Dilute with water and strain through a fine filter cloth held over the mouth of a filter funnel. Transfer the washed residue by means of a horn spatula to the casserole and boil for a further 30 seconds with 50 mls of a 2.5 per cent. solution of sodium hydroxide. Collect and wash the residue as before, mount, and examine. It will be found that the tissues disintegrate readily and are in a condition well suited to microscopical examination. For details of the quantitative estimation of crude fibre a paper by Goldberg * should be consulted.

B. CELL WALLS

The cell walls of plants, except those of many fungi, are largely composed of polysaccharides of high molecular weight. Similar substances occur as cell contents. These polysaccharides are conveniently grouped as *hexosans* if they yield hexose sugars on hydrolysis, *pentosans* if they yield pentose sugars, and *hexosan-pentosans* if they yield both hexose and pentose sugars. The hexosans are further known as *glucosans* if the sugar unit is glucose (*e.g.* starch and the true celluloses),

* Goldberg, *Y. B. Pharm.*, 1930, 375-389.

fructosans if the unit is fructose (*e.g.* inulin), and *mannans* and *galactans* if the sugar units are mannose and galactose respectively (*e.g.* endosperm of *nux vomica*). Pentosans and hexosan-pentosans appear to enter into the composition of hemicelluloses, gums, mucilages, and pectins.

Cell walls may become lignified, suberised, cutinised, or mucilaginous. When new material is added to the wall it frequently happens that certain parts of the wall receive no secondary thickening. Inequalities of thickening give rise to characteristic pits and sculpturings of the wall which are often of great diagnostic importance. The cell wall may break down either over a limited area as in the formation of wood vessels, and latex vessels, or over its whole area, as in the formation of lysigenous oleo-resin ducts and cavities, and in the gummosis leading to the formation of tragacanth (see Fig. 163).

Cellulose Walls.—A so-called cellulose wall consists of varying proportions of α -, β -, and γ -cellulose together with substances such as hemicelluloses and pectins. The colour reactions of such walls naturally vary with differences in chemical composition.

1. *Chlor-zinc-iodide* gives a blue colour with true celluloses and a yellow with pectic substances. Walls containing these in different proportions stain blue, violet, brownish-violet, or brown. Similar colours are obtained with iodine followed by concentrated acids.

2. *Iodine*, when used alone, gives no colour with true celluloses but may give a blue if hemicelluloses are present, *e.g.* in the cotyledons of tamarind seeds.

3. *Solution of Ammoniacal Copper Oxide B.P.* dissolves true celluloses, and on pouring the alkaline liquid into dilute sulphuric acid the cellulose is precipitated. Walls containing hemicelluloses, etc., are incompletely soluble in this reagent.

4. *Phloroglucinol and Hydrochloric Acid* gives no pink or red colour with cellulose walls.

Lignified Walls.—Lignification is brought about by the production of aromatic substances called lignins which are introduced into the polysaccharide layers of the cell wall. According to Mehta, lignin occurs in wood in a condition partly extractable by alcohol, but the major part is in combination with cellulose and related polysaccharides as aromatic glucosides. Lignocellulose, which is very widely distributed in plants, is hydrolysed by boiling with potash into lignin and cellulose.

1. *Caustic Soda and Bleaching Agents*, such as chlorinated soda and sodium sulphite, on boiling remove lignins from the cell wall leaving the cellulose. The latter usually forms about 50 to 60 per cent. of the wood.

2. *Phloroglucinol and Hydrochloric Acid* stain lignified walls pink or red. A similar colour is obtained when pentose sugars are warmed with this reagent.

3. *Chlor-zinc-iodide* stains lignified walls yellow.

Suberised and Cutinised Walls.—Suberin and cutin consist of glyceryl and other esters of acids such as suberic acid, $\text{COOH} \cdot [\text{CH}_2]_6 \cdot \text{COOH}$, although the acids present in the two substances are not identical. Suberin thickenings, such as are found in cork cells and endodermal cells, usually consist of carbohydrate-free suberin lamellæ. Cutin forms a secondary deposit on or in a cellulose wall. Leaves are frequently covered with a deposit of cutin which may show characteristic papillæ, ridges, or striations. The reactions of suberin and cutin are almost identical.

1. *Chlor-zinc-iodide* gives a yellow to brown colour.

2. *Soudan-Glycerin* colours both suberin and cutin red, especially on warming. The reagent is made by dissolving 0.01 G. of Soudan III in 5 mls of alcohol and adding 5 mls of glycerin.

3. *Strong Solution of Potash* stains suberin and cutin yellow. On warming suberin with a 20 per cent. solution of potash yellowish droplets exude, but cutin is more resistant.

4. *Diluted Tincture of Alkanna* stains the walls red.

5. *Concentrated Sulphuric Acid* does not dissolve suberin or cutin.

6. *Oxidising Agents.*—At ordinary temperatures concentrated chromic acid solution has little effect. When heated with potassium chlorate and nitric acid the walls change into droplets, which are soluble in organic solvents or in dilute potash.

Mucilaginous Cell Walls.—Certain cell walls may be converted into gums and mucilages. This gummosis may be observed in the stems of species of *Prunus*, *Citrus*, and *Astragalus* and in the testas of many seeds, e.g. linseed and mustard. In the case of the gum-yielding species of *Astragalus* gummosis commences near the centre of the pith and spreads outwards through the primary medullary rays (Fig. 163). The polysaccharide walls, excepting the primary membranes, swell and are converted into gum, the lumen, which frequently

contains starch, becoming very small. When the stem is incised whole tissues are pushed out by the pressure set up by the swelling of the gum. The commercial gum has a definite cell structure. The reactions of gums and mucilages are described below under cell-contents.

Chitinous Walls.—Chitin, $C_{32}H_{54}O_{21}N_4$, forms the major part of the cell walls of crustaceans, insects, and many fungi, *e.g.* ergot. It gives no reactions for cellulose or lignin. When heated with 50 per cent. potash at 160° to 170° for one hour it is converted into chitosan, $C_{14}H_{28}O_{10}N_2$, ammonia and acids such as acetic and oxalic. The mass may be dissolved in 3 per cent. acetic acid, and the chitosan reprecipitated by the addition of a slight excess of alkali. Chitosan gives a violet colour when treated first with a 0.5 per cent. solution of iodine in potassium iodide, and then with 1 per cent. sulphuric acid. The test may be applied to shrimp scales, first freed from carbonate by means of 5 per cent. hydrochloric acid, to the elytra of beetles, or to defatted ergot.

Sieve-Plates.—Sieve-tubes usually have cellulose walls and protoplasmic and other cell-contents. At the end of their vegetative period the sieve-plates become covered with callus which gradually closes the pores and limits the exchange of materials. Callus-plates consist of callose and have the following properties:—

1. *Alkaline Solution of Corallin, B.P.*, stains callose red.
2. *Aniline Blue* stains callose blue.
3. *Chlor-zinc-iodide* stains callose a reddish-brown.
4. *Solution of Ammoniacal Copper Oxide, B.P.*, does not dissolve callose.

5. *Solution of Potash.*—As even a cold 1 per cent. solution of potash dissolves callose this should not be used as a clearing agent if it is afterwards desired to test the section for callose.

C. CELL CONTENTS

The great diagnostic importance of starch and calcium oxalate in drugs has already been considered. Other cell contents are characteristic on account of their relative rarity, *e.g.* the cystoliths of calcium carbonate in the Moraceæ and Cannabinaceæ (see Fig. 41), inulin in the Compositæ and Campanulaceæ, and hesperidin and diosmin in the Rutaceæ and other families. A similar remark applies to the various classes of alkaloids, glycosides, anthraquinone derivatives etc.,

which, although they may be observed under the microscope, are usually best identified by chemical tests after they have been extracted by means of solvents.

Certain cell contents help to indicate the type of organ under examination, *e.g.* chlorophyll points to the presence of a leaf or herbaceous stem, while abundant aleurone, fat or fixed oil usually indicates a seed or fruit.

Secretions such as latex, mucilage, volatile oil, resin, oleo-resin, etc., are of some diagnostic importance, but the type of secretory tissue is often of more importance in this connection than the actual secretion. For example, latex is contained in vessels in the poppy and dandelion and in latex cells in *Euphorbia resinifera*; mucilage occurs in the epidermal cells of senna leaves and linseed and in the endosperm of fenugreek

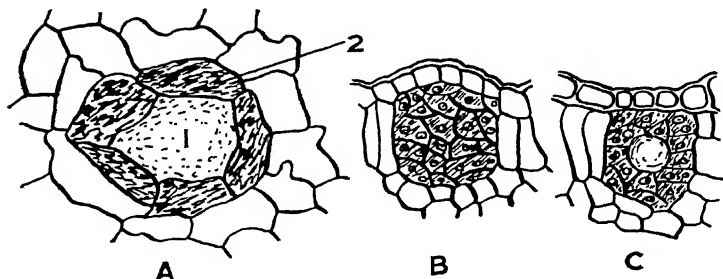


FIG. 44.—A, transverse section of a schizogenous secretory duct from the root of *Ferula foetida*; B and C, stages in the formation of a lysigenous oil cavity in the leaf of *Dictamnus albus* (Rutaceæ). 1, intercellular duct; 2, secretory epithelium. (A after Tschirch, B and C after Rauter.)

seeds. Volatile oil may be found in glandular hairs (*e.g.* Labiatae), oil cells (*e.g.* pepper, mace, and cardamoms), schizogenous ducts (*e.g.* the vittae of the Umbelliferae), or in lysigenous or schizolysigenous cavities (*e.g.* Rutaceæ). A schizogenous duct, it may be mentioned, is one formed by splitting, an intercellular space arising surrounded by an epithelium of secretory cells (Fig. 44, A). A lysigenous cavity, on the other hand, is formed by the gradual breaking down or solution of the walls of certain cells (Fig. 44, B and C). What frequently happens is that a space is first formed schizogenously and afterwards increases in size lysigenously. Resins, oleo-resins, and gum-resins also occur in different types of secretory structure, *e.g.* intercellular glands (male fern), cells (ginger), schizogenous

ducts (crude turpentine and asafetida), or in cavities (copaiba and myrrh).

Albuminous Substances and Aleurone Grains.—Proteins dissolved in the cell-sap may frequently be precipitated by means of alcohol or they may separate from the vacuoles in solid form. Such aleurone grains are common in seeds and attain their largest size in oily seeds such as linseed. Proteins known as albumins and globulins take part in their formation. Albumins are water-soluble, whilst globulins although insoluble in water are soluble in dilute salt solutions. In the formation of an aleurone grain the albumin frequently takes the form of one or more crystalloids, which differ from other crystals in that they may be stained. The grain may also contain one or more globoids which consist of globulins combined with the calcium and magnesium salt of inosithexa phosphoric acid. An aleurone grain thus consists of ground-substance containing a variable number of crystalloids and globoids and sometimes calcium oxalate, which is usually in the form of minute rosettes.

On adding *Millon's reagent* to a protein solution a white precipitate is produced which becomes red on heating. *Iodine solution* gives a yellowish-brown colour with the ground substance and crystalloid of an aleurone grain, but the globoid remain uncoloured. An aqueous *solution of picric acid* stains the ground substance and crystalloid yellow, but does not stain the globoid. A 0.3 per cent. *solution of potash* dissolves ground substance and crystalloids leaving the globoids.

To differentiate the different parts of an aleurone grain stain with *alcoholic solution of eosin*, rinse with oil of cloves, then with xylene and mount in balsam. The ground substance is coloured red, the crystalloids yellow, and the globoids remain colourless.

Alkaloids are usually best identified by ordinary chemical methods after extraction from the plant. Microchemical tests are, however, useful for obtaining information as to the localisation of alkaloids* in the plant (cf. strychnine in *nux vomica*, p. 549, and colchicine in *colchicum*, p. 236). As a general reagentsolution of iodine in potassium iodide may be used. This produces reddish-brown precipitates with most alkaloids. Its effect on the alkaloid-containing sections should be compared with its action on sections from which the alkaloids have been removed by soaking in an alcoholic solution of tartaric acid.

* See Wagenaar, *Pharm. Weekbl.*, 1934, 71, 834.

Calcium Carbonate may be found embedded in or incrustated on the cell-walls, *e.g.* the cystoliths found in the hairs of *Cannabis sativa* (Fig. 41, M). It may be identified by the fact that it dissolves with effervescence in acetic, hydrochloric, or sulphuric acid. If 50 per cent. sulphuric acid is used, acicular crystals of calcium sulphate gradually separate.

Calcium Oxalate.—The crystalline forms of calcium oxalate are described on pp. 82 and 94. The salt differs from calcium carbonate in that it is insoluble in 33 per cent. acetic acid and soluble, but without effervescence, in hydrochloric or sulphuric acid. With sulphuric acid acicular crystals of calcium sulphate gradually separate.

Fats and Fixed Oils.—Fats occur in solid, frequently coloured or crystalline, masses which melt on warming. Fixed oils occur as small highly refractive drops. Both are soluble in ether-alcohol, but, with a few exceptions, such as castor oil, are sparingly soluble in alcohol. They are coloured brown or black with a 1 per cent. solution of osmic acid, and red with a diluted tincture of *alkanna*. The latter stains rather slowly and should be allowed to act for at least 30 minutes. A cold mixture of equal parts of a saturated solution of *potash* and strong solution of *ammonia* slowly saponifies fixed oils and fats. After some hours characteristic soap crystals may be observed.

Gums and Mucilages.—Gums, mucilages, and pectins are complex compounds of polysaccharide nature. On hydrolysis they usually yield sugars (hexoses and pentoses) and oxidation products of sugars known as uronic acids (see *tragacanth*, p. 484, and *acacia*, p. 491). Polyuronic acids have been obtained from other gums, from linseed mucilage, from the alginic acid of seaweeds (see p. 181), and from orange and apple pectins. These polysaccharide complexes are frequently combined with metals.

Gums and mucilages are insoluble in alcohol but dissolve or swell in water. They are usually formed from the cell-wall, *e.g.* *tragacanth*, or deposited on it in successive layers. When such cells are mounted in alcohol and irrigated with water the stratification may often be seen, *e.g.* *mustard* and *linseed*.

Specific tests for these substances are at present lacking, but the following are useful. The official *Solution of Ruthenium Red* stains the mucilage of *senna* and *buchu* leaves, *althæa*, *linseed*, and *mustard*. It also stains *sterculia* gum but has no action on *tragacanth*. The lead acetate medium is used to prevent undue swelling or solution of the substance being

tested. Some forms of mucilage are stained by the official *Alkaline Solution of Corallin*, e.g. that found in squill. Others are stained by *chlor-zinc-iodide* or *methylene-blue* dissolved in alcohol and glycerin.

Inulin occurs either in solution in the cell-sap or in amorphous or sphaerocrystalline masses. The latter form occurs in alcohol-preserved material. Inulin is sparingly soluble in cold water but readily dissolves in water at about 70° without gelatinising. It is not stained by *iodine*. When tissues containing inulin are treated first with a 10 per cent. *alcoholic solution of α -naphthol* and then with a few drops of *concentrated sulphuric acid* and warmed, a violet colour is produced.

Resins may be associated with volatile oil or gum or may be found in irregular masses which are insoluble in water but soluble in alcohol. They stain slowly with diluted *tincture of alkanna*. Some resinous secretions become more evident after treatment with *solution of iodine*, e.g. ginger and jalap resins, whilst others, e.g. colophony, are coloured green after soaking for about a week in an aqueous *solution of copper acetate*.

Silica forms the skeletons of diatoms (see agar, p. 183, and kieselguhr, p. 148) and occurs as an incrustation on cell-walls or as masses in the interior of cells, e.g. in cardamom seeds. Silica is insoluble in all acids except hydrofluoric. It may be examined by igniting the material and treating the ash with hydrochloric acid, the silica remaining unaltered.

Starch.—The effect of iodine, chloral-iodine, chlor-zinc-iodine, acids, alkalies, and heat should be noted. The examination should be conducted so as to give information as to the relative amount of starch present, its type (simple or compound grains), shape, size, hilum, striations, and behaviour in polarised light.

Tannins are best examined after extracting from the drug as described in Chapter XXIV. If it is desired to study the distribution of the tannins in the plant the sections must be cut dry, since tannins are soluble in water and alcohol. If sections of galls are so cut and mounted in clove oil plates of tannin may be observed. Sections containing tannins acquire a bluish-black or greenish colour when mounted in a dilute *solution of ferric chloride*.

Volatile Oils are sparingly soluble in water but dissolve in alcohol (cf. fixed oils). They resemble fixed oils (*q.v.*) in their behaviour towards *osmic acid* and *tincture of alkanna*, but they are not saponified when treated with *ammoniacal-potash*.

CHAPTER XI

FIBRES, FILTERING MEDIA, AND SURGICAL DRESSINGS

THE fibres, filtering media, and surgical dressings in common use are easily identified by microscopical examination and chemical tests. The term surgical dressings includes bandages (*L. ligamentum*), gauzes (*L. carbasus*), towels (*L. stupa*), plasters (*L. emplastrum*), tissues (*L. tela*), sheep's wool (*Lana*), silk (*Scricum*), absorbent cotton wool (*Gossypium Absorbens*), medicated cotton wools, and various protectives such as oiled silk, oiled cambric, jaconet, and battiste. As medicated dressings are usually dealt with in pharmaceuticals, only unmedicated dressings, fibres, and filtering media are considered here.

Fibres, and Filtering Media

A few preliminary tests will suffice to group the material under examination into one or other of the following groups :—

Group I. *Animal fibres, e.g.* wool and silk.

Group II. *Vegetable fibres :—*

(a) Cellulosic, *e.g.* cotton, white filter paper, delignified wood pulp, and flax.

(b) Lignified, *e.g.* jute (tow), mechanical wood pulp.

Group III. *Inorganic, e.g.* diatomite (purified kieselguhr), chalks, talc, glass wool, and asbestos.

Preliminary Tests.—1. Heat the substance in an ignition tube. Vegetable and animal fibres char and burn leaving little ash, whilst inorganic matter undergoes little visible change. The difference in odour usually serves to distinguish the animal from the vegetable.

2. Boil for 5 minutes with a saturated solution of picric acid and wash thoroughly. Only animal fibres take a yellow stain.

3. Molisch's test : To about 0.01 G. of the washed fibre add 1 mil of water, two drops of a 15 per cent. alcoholic solution of α -naphthol, and 1 mil of concentrated sulphuric acid. If the fibre is vegetable the liquid becomes deep violet on shaking.

4. Treat the fibre with phloroglucinol and hydrochloric acid. Only lignified fibres stain pink.

WOOL (LANA); ANIMAL WOOL ; SHEEP'S WOOL

Preparation.—Wool is prepared from the fleece of the sheep, *Ovis aries* (Order Ungulata), by cleansing and washing. The length and quality of the hair varies not only from animal to animal but in different parts of the same fleece. In order to get more or less uniform grades the wool-sorter spreads each fleece on a frame covered with wire-netting and separates it into wool of different qualities. At the same time he beats much dust and dirt through the netting and picks out burrs and pieces of straw. The wool is washed in tanks of warm, soft, soapy water, being squeezed between rollers as it passes from one tank to the next.

The approximate composition of raw wool is as follows: wool fibre 31 per cent.; "wool sweat" or "suint," consisting mainly of the potassium salts of fatty acids, 32 per cent.; earthy matter removable by washing 26 per cent.; and "wool grease."

From the washings of the scouring process "wool grease" may be separated by mechanical means or by the use of organic solvents. When purified it is known as wool fat or anhydrous lanolin. Potassium salts may also be recovered. After washing, the wool is dried, the fibres mechanically loosened, carded, and spun into yarn. The fineness of wool yarn is the number of hanks each of 560 yards that make a weight of 1 lb.

Microscopy.—The hairs originate in relatively deep pits or hair follicles in the skin and the "wool grease" is secreted by neighbouring sebaceous glands. If fibres of raw wool are examined under the microscope they are seen to be covered with irregular masses of grease, the structure of the hair itself being indistinct. If raw wool is to be mounted for microscopical examination it should be defatted by ether or chloroform, as it will not otherwise wet with water; even with scoured wool it is advisable to moisten the threads with alcohol before mounting in water, dilute glycerin, or solution of picric acid.

Wool hairs are from 2 to 50 cm. in length and from 5 to 100 μ , usually 13 to 40 μ , in diameter. As the fleeces are removed by shearing, the bases of the hairs are lacking and the tapering ends, known as "lamb ends," are only found in wool from the first shearing. As we focus down the three regions of the hair, known as the cuticle, cortex, and medulla, may be distinguished.

Cuticle.—This consists of imbricated, flattened, more or less translucent epithelial scales. The shape and arrangement of the scales varies in different breeds of sheep, the edges being smooth and straight in some and serrated and wavy in others. The number of scales in 100μ length is fairly constant, averaging about 9.7 to 12.1, in different wools. Such counts may be used to distinguish sheep's wool from angora wool, etc.

Cortex.—The cortex consists of elongated, fusiform cells coalesced into a horny mass in which scattered pigment cells are sometimes found. When observed through the epithelial scales, the cortex appears as delicate longitudinal striations.

Hairs which have been damaged by bacteria so as to lose parts of their epithelium show a "brush-end" effect in which the individual fibres may be easily seen. Strong solution of ammonia causes the epithelial scales to separate in a few minutes and facilitates examination of both scales and cortical fibres.

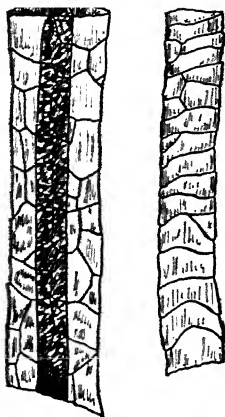


FIG. 45.—Fibres of sheep's wool. (After Hanausek.)

Medulla.—The medulla consists of rounded or polyhedral cells containing fatty matter or pigment, and is best seen when its cells contain much air or pigment. It frequently shows well if a hair has been soaked in alcohol and allowed to dry or when hydrochloric acid is used as the mountant. The medulla varies in diameter and is not continuous throughout the length of the hair.

Tests : A. Characteristic of Animal Fibres :—

1. Gives no violet colour with Molisch's test.
2. Coloured yellow with picric acid or nitric acid.
3. Coloured red with boiling Millon's reagent.
4. Rapidly soluble in 5 per cent. potash.

B. Characteristic of Wool :—

1. Ammoniacal copper oxide solution resembles solution of ammonia in that it causes separation of the scales ; it also colours the fibres blue.

2. When lead acetate is added to a solution of wool in caustic soda a black precipitate is formed owing to the high sulphur-content (distinction from silk).

3. Wool is not appreciably soluble in warm hydrochloric acid (distinction from silk), or in cold concentrated sulphuric acid (distinction from cotton).

SILK (SERICUM)

Preparation.—Silk is the prepared fibre from the cocoons of *Bombyx mori*, the mulberry silkworm, and other species of *Bombyx* and of *Antheraea* (Order Lepidoptera). Silk is produced in China, Japan, India, Asia Minor, Italy, France, and many other countries. Whilst the silk of *Bombyx mori* forms the greater part of that used, considerable quantities of the so-called wild silks are produced by *Antheraea mylitta* (India), *A. assama* (India), *A. pernyi* (China), and *A. yama-mai* (Japan).

Before the silkworm passes from the caterpillar to the chrysalis or pupal stage it secretes around itself an oval cocoon about 2 to 5 cm. long, consisting of a continuous thread up to 1,200 metres long. This thread consists of two silk or *fibroin* fibres cemented together by a layer of silk glue or *sericin*. Strands of semi-liquid fibroin, produced by two glands in the insect, flow into a common exit-tube in the head, where it meets the secretion of silk glue produced by another pair of glands. The double fibre with its coating of sericin emerges from a spinneret in the head of the worm, coagulates and hardens on contact with the air, and is spun into the cocoon by figure-of-eight movements of the head. If the chrysalis were allowed to mature the silk would be damaged by the escaping insect. It is therefore killed by heating at 60° to 80° for a few hours or by a short exposure to steam. The cocoons are then graded, placed in hot water, and beaten to facilitate removal of the outer layer of fibre, which is only of secondary value, and to soften the silk glue.

The double fibre in the cocoon is known as a *bave* and its constituent fibres as *brins*. The reeler takes the loose ends of the fibres of from 2 to 15 cocoons and twist and reels them into single thread. Most raw silk is reeled from about 5 cocoons and therefore has 10 brins, fibres containing less than 6 brins being too fine for commercial purposes. Silk is then usually scoured by treatment with hot soap solution to remove the sericin, the process being known as stripping or degumming. For some purposes, however, half-scoured silk is used.

Microscopy.—Place a piece of oiled silk on a microscope slide and examine with a $\frac{1}{8}$ -in. objective. It will be noted

that each thread consists of about 10 brins which have separated from one another so that counting is easy (see Fig. 46). Next examine some fibres of raw silk mounted in water; note that the diameter of these is several times that of a single brin, that the individual brins may be seen, although difficult to count, and that flakes of silk glue may be seen on the surface. If a little of this raw silk is now boiled with soap solution or dilute sodium carbonate solution the sericin completely dissolves and the constituent brins may be mounted and examined.

The lack of cellular structure and the breadth of the brins are distinguishing characters of mulberry silk. Brins of

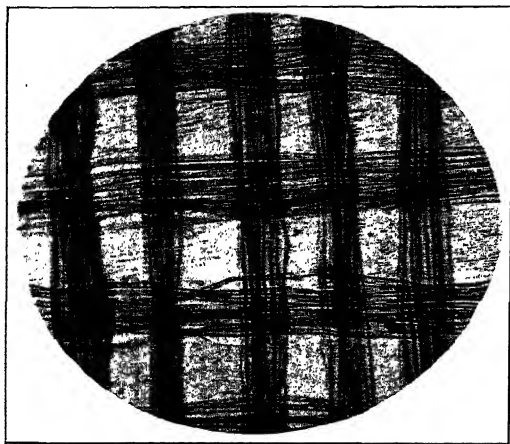


FIG. 46.—Oiled Silk.

mulberry silk measure $10-21\mu$ (mostly about 16μ), whereas those of wild silks are about $30-60\mu$. The latter often show well-marked longitudinal striations.

Tests : A. Characteristic of Animal Fibres :—Silk resembles wool in its behaviour with Molisch's test, picric acid, nitric acid, and Millon's reagent. It is more resistant to potash, but does dissolve on heating.

B. Characteristic of Silk :—

1. Silk is soluble in ammoniacal copper oxide solution. An alkaline solution of copper sulphate and glycerol of a certain strength is used for theseparation of silk from wool and cotton.*

* For details, see Matthew's *Textile Fibres*, p. 308.

2. Silk contains little or no sulphur and therefore gives no black precipitate when a solution in potash is treated with lead acetate (distinction from wool).

3. Silk dissolves in a moment or two in concentrated hydrochloric acid (distinction from wool).

COTTON (GOSSYPIMUM); RAW COTTON

Source.—Cotton consists of the epidermal trichomes of the seeds of *Gossypium herbaceum* and other cultivated species of *Gossypium* (Fam. *Malvaceæ*). The plants are shrubs or small trees which produce 3 to 5-celled capsules containing numerous seeds. The U.S.A. produces about half the world's cotton, other important sources being Egypt, India, and South America. The chief American cottons are derived from *G. barbadense* (Sea Island cotton) and *G. herbaceum* (Upland, Texas, or New Orleans cotton).

The hairs of the different species vary in length or "staple." According to the grading of the New York Stock Exchange, cottons the average fibre of which is under 25 mm. in length are called "short staple"; those between 25 and 30 mm. "medium staple"; and those from 30 to 40 mm. "long staple." The staples of important commercial varieties of cotton are as follows:—

1. Sea Island, up to 54.5 mm.
2. Egyptian, 31 to 38 mm.
3. Brazilian and Peruvian, 29 to 30 mm.
4. American Upland, about 25.9 mm.
5. Indian, 21.4 to 29.2 mm.

Preparation.—When ripe, the bolls are collected, dried, and subjected to a ginning process to separate the hairs from the seed. The gin, which may be of a roller or pneumatic type, is designed to pull the hairs through a narrow space which is too small to allow the seed to pass. In ordinary American or Upland cotton the gin leaves the seeds with a coating of short hairs which have to be removed by a second type of gin known as a "linter." These short hairs are used for making guncotton and the lower grades of cotton wool (*q.v.*). The seeds are used for the preparation of cotton seed oil (*q.v.*) and cattle cake. Raw cotton contains various impurities, such as immature and broken seeds, fragments of leaf, etc., most of which are removed during the manufacture of yarn.

The *fineness* or *count* of cotton yarn is the number of hanks, each of 840 yards, that make a weight of 1 lb. For spinning very fine yarns (up to 300's) Sea Island cotton is used, but for coarser yarns (under 80's) it is possible to use shorter staple cottons. Different machines are used for these two types of

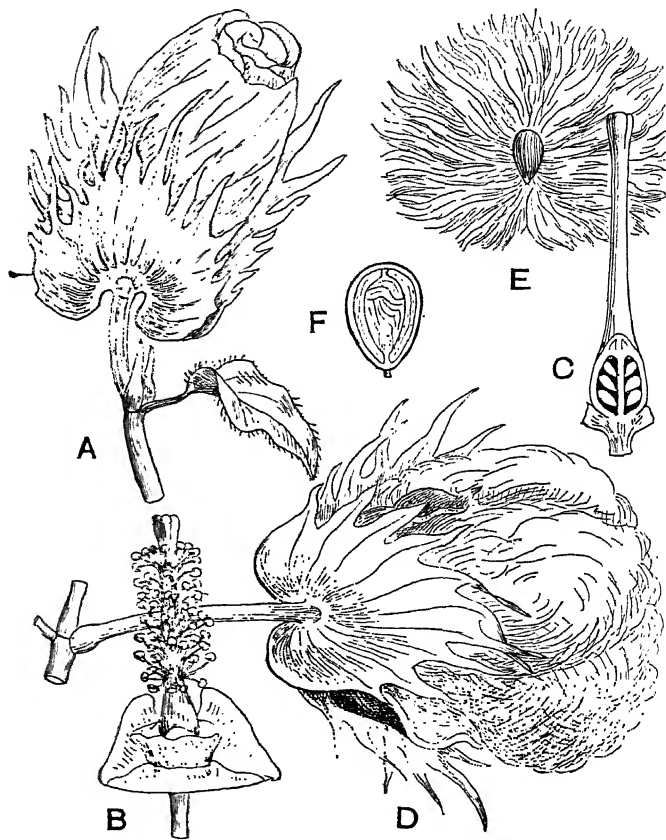


FIG. 47.—*Gossypium barbadense*. A, flower about to open, $\times \frac{2}{3}$; i, involucre of bracts; B, flower with calyx and corolla cut away, showing staminal tube enclosing pistil, $\times \frac{2}{3}$; C, pistil with ovary cut lengthwise, nat. size; D, capsule open showing mass of cotton, $\times \frac{2}{3}$; E, seed with cotton attached, $\times \frac{2}{3}$; F, seed cut lengthwise, showing twisted embryo, $\times 1\frac{1}{2}$. (From Rendle's *Classification of Flowering Plants*.)

yarn, which are known as *combed* and *carded* respectively. The cotton-combing machine separates all the shorter fibres and a thread is spun consisting of long, well-paralleled, uniform fibres. The short fibres of *comber waste* are used for making the best grades of cotton wool. The carding machine uses

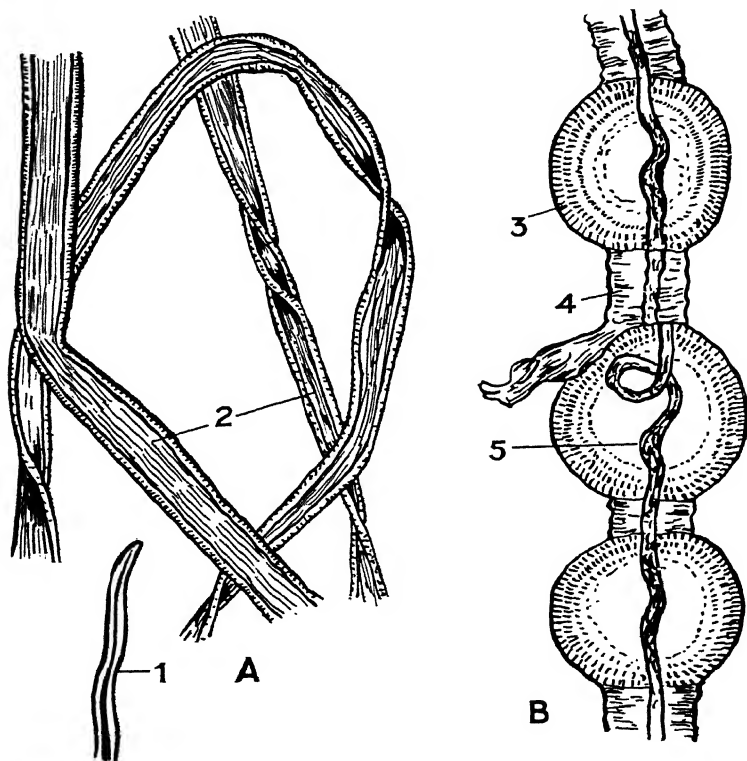


FIG. 48.—Cotton. A, mounted in water; B, mounted in cuoxam. 1 apex of hair; 2, central portions of hairs; 3, swollen cellulose wall; 4, rings of cuticle; 5, inner membrane of hair. (After T. F. Hanausek.)

fibres which are shorter and less uniform in length, and the absence of combing is shown in the yarn by the irregular arrangement of the fibres, the ends of which often project from the surface. Standards for fineness of yarn in *B.P.C.* surgical dressings should be noted. It will be observed that the

yarns used are relatively coarse and may be unbleached (Unbleached Calico Bandage) or bleached (Muslin Bandage).

Microscopy of Unbleached Cotton.—Cotton consists of unicellular hairs the appearance of which has been likened to that of empty, twisted fire-hoses. Their length is up to about 5 cm., diameter 9 to 24μ , and the number of twists varies from about 150 per inch in the Indian to 300 per inch in the Sea Island. Pieces of "shell" or seed coat, which can often be picked from samples of raw cotton, show hair bases fitting between the thick-walled epidermal cells. The apex is rounded and solid (Fig. 48). The cotton hair is cylindrical when young, but becomes flattened and twisted as it matures, the large lumen, which contains the remains of protoplasm, being much elongated in transverse section. Students will find it more convenient to examine prepared slides of transverse sections of this and other fibres rather than cut them themselves. The cellulose wall of the hair is covered with a waxy cuticle which renders it non-absorbent. Samples of raw cotton and of unbleached cotton yarn should be moistened with alcohol, mounted in water, and sketched. The following tests should be made.

Tests.—**A. Characteristic of Vegetable Fibres :—**

1. Gives a violet colour with Molisch's test.
2. Not permanently stained by boiling picric acid.
3. Not coloured red by boiling Millon's reagent.
4. Insoluble in 5 per cent. potash.

B. Characteristic of Cotton :—

1. Cotton gives no pink or red colour with phloroglucinol and hydrochloric acid (distinction from lignified fibres such as kapok and jute).

2. When mounted in ammoniacal solution of copper oxide some of the fibres usually show balloon-like swellings similar to those in Fig. 48B. All samples of raw cotton do not show this to the same extent, but samples of Egyptian usually show the phenomenon well. As the swelling is very rapid with the undiluted reagent, it may be necessary to dilute it with about an equal volume of distilled water. Points to notice are the ring-like constrictions of cuticle, the swollen, blue cellulose wall, and the inner membrane. The latter is fairly resistant to the reagent and often remains for a time as a narrow, twisted tube showing diagonal and spiral markings. The wall gradually dissolves until only a few fragments of cuticle remain.

3. Moisten with iodine solution and stand until nearly dry. Then add a few drops of 66 per cent. sulphuric acid, cover, and examine. The cells assume a reddish or bluish violet colour. The presence of the cuticle is partly responsible for the colour, for if transverse sections are similarly treated the cuticle stains yellow and the wall blue. If the cuticle is removed, as in absorbent cotton wool, or caused to rupture by the swelling of the wall with stronger sulphuric acid (about 80 per cent.), a blue colour is obtained. Strong acid is to be avoided, as it causes rapid disintegration of the hairs.

4. Chlorzinciodine solution gives a reddish or bluish-violet colour.

5. Cotton dissolves in cold, concentrated sulphuric acid (distinction from wool).

ABSORBENT COTTON WOOL (GOSSYPIMUM ABSORBENS); ABSORBENT WOOL.

Cotton wool is mainly prepared from linters, card strips, card fly, and comber waste. Bales of these short-fibred cotton wastes pass from the yarn manufacturers to the makers of cotton wool. For best quality cotton wool the comber waste of American and Egyptian cottons is preferred. In this the fibres are reasonably long and twisted and thus suitable for producing a cotton wool having an average staple of not less than $\frac{5}{8}$ in., which will offer appreciable resistance when pulled. The preparation may be divided into two stages, bleaching and carding, which have been described as follows * :—

Bleaching.—"The material is usually passed through a short range of cotton 'opening' machinery, such as the Bale breaker and/or the Crighton opener, in order to loosen it sufficiently to facilitate the subsequent 'wet' processes. After being 'opened,' the cotton is put into a kier. This is a large iron vessel with suitable apertures for loading and unloading. When the kier is loaded (it usually holds from $1\frac{1}{2}$ to 2 tons), the material is boiled, under pressure, with a weak solution of caustic soda and soda ash. The pressure used varies with the qualities treated, and may be anything from 1 to 3 atmospheres. The boiling continues for fifteen hours, after which the liquor is allowed to drain off. The hot mass of cotton is then subjected to a lengthy treatment of clean cold water in order to wash the last traces of soda from it.

"After thorough washing, the cotton is lifted from the kier and placed in a bleaching cistern. The latter may be constructed of iron.

* Surgical Dressings : The Manufacture of Cotton, by J. Wicliffe Peck, P.J., 1933, Oct. 21, 484.

brick, stone, or slate. In any case, it should be covered on the inside with an acid-resisting asphalt. Bleaching is usually done with a weak solution of calcium or sodium hypochlorite. The time taken to get a good result varies from ten to eighteen hours. When the operation is finished, the liquor is drained off, the material washed with clean water, and treated with a very dilute solution of hydrochloric acid for about four hours, after which the cotton is again thoroughly washed with cold water. It is then dried by passing it through a hot air machine, the temperature of which varies from 110° F. to 180° F., according to its size and the amount required to be done in a given time."

Carding.—"During bleaching, the fibres become matted and must be loosened before carding. For this purpose the machines generally used are a 'Willow,' followed immediately by a 'Buckley opener';

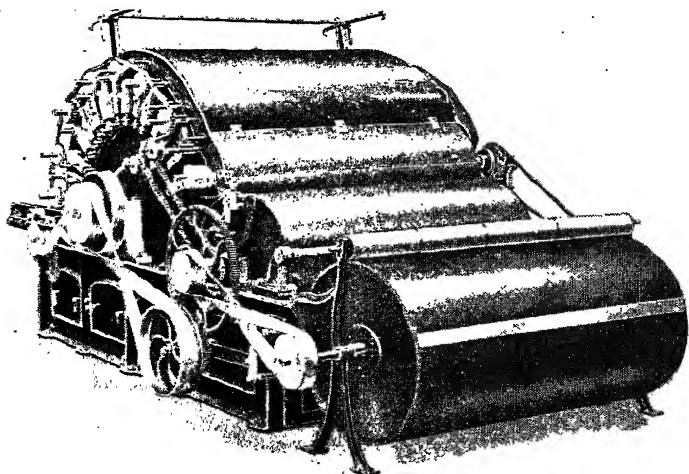


FIG. 49.—A carding machine fitted with a lap drum for cotton wool
(*The Pharmaceutical Journal*).

alternatively a 'Bale breaker,' followed by a 'Crighton opener' are used. The object of both combinations is to obtain a general opening-up of the fibres. When this is done, it is usual to pass the opened cotton forward to a set of machines called the hopper feeder and scutchers which are designed to open up the cotton still further, and eventually turn it off in a continuous sheet of a fairly even thickness; the material is rolled by this machine into a lap ready for the carding process.

"The hopper feeder is a box or hopper fitted with a vertical spiked lattice which carries the cotton upwards; at the top, this lattice is met by a horizontal spiked lattice working in the opposite direction and set at a given distance from the top of the first lattice. The second or horizontal lattice takes back any surplus cotton and so regulates the

thickness of material being delivered by the hopper feed to the scutcher. From the hopper feed the cotton falls in a fairly regular thickness on to a horizontal lattice moving slowly to the feeding end of the scutcher. It is then passed between a pair of fluted steel rollers, which present the cotton to the action of the scutcher beater. At this point the rollers not only hold the cotton firmly whilst a further beating is performed, but a further effort is made to prevent inequality in the weight of the resultant out-turn. This is done by automatically reducing or accelerating the speed of the steel rollers, according to the thickness of material passing this point from time to time.

"Having formed the scutcher lap, it is now ready for the carding machine, which is, in effect, a definite combing operation designed to produce the cotton in a long, continuous film and put it into the condition which we call 'cotton-wool.' The scutcher lap is taken to the feed end of the card and unrolled slowly. After passing through a pair of steel fluted rollers, and whilst still held firmly by them, it is brought into the path of a saw-tooth roller, which travels at a high speed. This roller splits up the fibres very minutely, and passes them on to a large cylinder, clothed with wire pins, set about 90 to 100 to the square inch. Superimposed on this cylinder are a number of small rollers, which are covered with similar wire to that on the cylinder. The rollers are set very close to it, and run in the same direction. It should be explained that the wire pins on both the rollers and the cylinder are bent so as to be presented to the cotton at an angle.

"The rollers, or 'workers,' as they are called, run very much slower than the cylinder, and set up a combing action on the fibres which happen to be passing between them and the cylinder. As the work progresses, any fibres which adhere to the wire pins of the 'worker' are taken off by another wire-covered roller, which is set very close to it and is known as the 'clearer.' This latter, in turn, puts the fibres which it takes from the 'worker' back on to the wire-covered face of the cylinder. This operation is performed in six or seven positions, spaced out as equally as possible on the top half of the cylinder.

"To take the fibres off the large cylinder at the delivery end of the machine a smaller cylinder rotating in the opposite direction to the large cylinder and set very close to it picks off the carded fibres from the main cylinder. The small cylinder is known as the 'doffer'; a steel comb of special construction is fitted to the front of the 'doffer' working with an oscillating motion, and this combs off the carded fibres into a continuous film. These films of carded cotton are allowed to build up into thick fleeces by a special arrangement at the delivery end of the machine. The fleeces so built up are conveyed to a machine which rolls up the cotton into the form in which it is generally seen in hospitals and shops and at the same time interleaves it with paper."

Microscopy of Bleached Cotton.—Absorbent cotton wool and the fibres from bleached cotton yarns differ from raw cotton in the following respects :—

1. The fibres are readily wetted by water.

2. When mounted in an ammoniacal solution of copper oxide the fibres do not show a balloon-like swelling ; the wall becomes blue, swells uniformly, and dissolves leaving much less debris than in the case of raw cotton.
3. With iodine and sulphuric acid or with chlorzinciodide a better blue colour is obtained. A blue colour with iodine alone would indicate the presence of hydroxycellulose (see below).

Chemical Nature of Cotton.—Analyses of typical raw cottons may be summarised as follows :—

	<i>Average, per cent.</i>
1. Dry at 100° for moisture ..	
2. Ignite for ash of raw cotton ..	
3. Boil with alkali for fat and wax ..	5.00
4. Bleach for colouring matters ..	0.50
5. Boil with sodium sulphite for cuticular substances ..	0.75
6. Ignite ; loss gives cellulose ..	86.63
7. Ash of cellulose	0.12

Absorbent cotton is a very pure form of cellulose and is termed a normal cellulose to distinguish it from other types in which cellulose is associated with pectic substances (*e.g.* flax) or lignin (*e.g.* jute).

Pyroxylin and *Guncotton* are nitrated celluloses formed by the action of a mixture of nitric and sulphuric acids on cotton. Cotton when boiled with moderately concentrated nitric acid or other oxidising agents is partly converted into *hydroxycellulose*. Some samples of white filter-paper contain appreciable quantities of hydroxycellulose. When this is present the fibres give a blue colour with iodine, reduce Fehling's solution, and dye more readily than ordinary cellulose fibres with basic dyes such as methylene blue.

WOOD PULPS AND FILTER PAPERS

The chief stages of paper manufacture are the disintegration, cleaning, and bleaching of the raw materials ; pulping ; moulding ; pressing into sheets and drying. The raw materials from which papers are made include *wastes*, such as cotton and other rags, sacking, ropes, and old paper ; *stems*, such as esparto, straw, and bamboo ; *pulps*, such as mechanical and chemical wood pulps. In addition to these fibrous materials, papers may contain colouring matters, sizes such as gelatine and colophony resin, and fillings such as china clay. *Imitation art papers*, for example, may contain up to 25 per cent. of china

clay. The good quality *writing papers* contain a high proportion of rags, whereas *newspapers* commonly contain about 70 to 80 per cent. of a mixture of mechanical and chemical wood pulps. It may be pointed out that *oiled paper* (*Charta Oleata B.P.C.*) must not contain more than a certain percentage of mechanical wood pulp or mineral matter (filling). *Parchment papers* are made by rapidly passing unsized paper through sulphuric acid, washing, neutralising, and drying. The chief characteristics of *filter and blotting papers* are their high absorbency, low tensile strength, and chemical purity. White filter paper and the better quality blottings are made from soft muslin rags. Blottings made from wood pulps are less absorbent, but may be used for interleaving diaries, etc. Wood pulps are also used as filtering media and as absorbent surgical dressings.

Mechanical Wood Pulp is made from coniferous woods, *e.g.* pine, fir, spruce, and from angiospermous woods, *e.g.* poplar and willow. The bark is removed from the logs and the wood is pressed by hydraulic presses against revolving grindstones over which water continually flows. Chemical wood pulp (see below) is not prepared in this way, as the grinding shortens the fibre too much. Bleached mechanical wood pulp, prepared by treating mechanical wood pulp with chlorine, is, however, obtainable.

For microscopical examination wood pulps should be mounted in water and in phloroglucinol and hydrochloric acid. Mechanical wood pulp gives a well-marked lignin reaction (distinction from chemical pulps). Coniferous wood pulps in general exhibit tracheids with bordered pits, whereas angiospermous pulps are characterised by different types of vessels and wood fibres. Other characteristics such as the medullary ray cells serve to distinguish individual woods. For example, in firs the medullary ray cells have simple pits and in spruce small bordered pits, whilst in pines both bordered pits and teeth-like thickenings of the walls may be observed.

Chemical Wood Pulps.—Three types of chemical wood pulp are made in quantity, namely, sulphite pulp, soda pulp, and sulphate pulp. These may be distinguished by the amount of chloroform extract they give, sulphite yielding 0.5 to 1.0 per cent., whilst sulphate and soda give 0.2 per cent. or less.

1. *Sulphite Pulp.*—Wood chips are digested in a solution of sulphurous acid and calcium acid sulphite, $\text{Ca}(\text{HSO}_3)_2$, at 65 to 70 lb. pressure for about 20 hours. These reagents remove

lignin and hydrolyse polysaccharides, but have little effect on cellulose. It may be necessary to bleach the pulp with a hypochlorite solution or other bleaching agent, but for many purposes this is unnecessary. The pulp is thoroughly washed, passed through press rolls, cut into boards, and dried. It is from bleached sulphite pulp that cellulose wadding is made.

2. *Soda Pulp* is made by digestion with a 7 to 8 per cent. solution of sodium hydroxide at a pressure of 100 to 130 lb. The pulp is greyish unless afterwards bleached.

3. *Sulphate Pulp* takes its name from the employment of a crude mixture of neutral and acid sodium sulphates obtained as a by-product in the manufacture of nitric and hydrochloric acids. This mixture is reduced by heating with carbon and lixivitated to give the solution in which the wood is digested. It contains about 4 to 6 per cent. of sodium hydroxide and 1.5 to 4.0 per cent. of sodium sulphide, the latter forming more sodium hydroxide and sodium hydrosulphide by hydrolysis. The wood is digested for 3 or 4 hours at 100 lb. pressure.

Cellulose Wadding (Cellulosum Ligni).—This is prepared from high-grade bleached sulphite pulp, which is received by the manufacturer in the form of boards about 2 ft. square and 0.04 in. thick. These are packed in bales containing about 400 lb. pulp. The pulp is put in a "beater," where it is mixed with about twenty times its weight of water, and the mixture circulates between a power-driven roll and the bed-plate of the "beater." The effect of this is to break up the pulp into separate fibres. When this process is complete the contents of the beater are mixed with a further quantity of water and then allowed to run in a steady flow on to the "wire" of the paper machines. This "wire" is a very fine wire gauze through which the water runs, leaving a fine web of fibres on top of the "wire." This web is then dried and creped to give a thin, soft, absorbent sheet. About 30 of these thin sheets are laid together to form cellulose wadding.

When examined microscopically chemical wood pulps or cellulose wadding show characteristic woody elements which, however, give no lignin reaction (distinction from mechanical wood pulp). Tracheids with bordered pits and characteristic medullary ray cells are usually observed. The cellulose nature of the walls is shown by the blue colour obtained with iodine followed by 80 per cent. sulphuric acid, and by their solubility in an ammoniacal solution of copper oxide. The *B.P.C.* test for absorbency should be noted.

White Filter Papers.—"All-rag" fibre is usually used for white filter papers. Rags, already sorted into some twenty or thirty grades, are available to paper manufacturers. A grade consisting largely of soft muslin, which is too soft for writing papers, is well suited to the manufacture of filter and blotting papers. These rags are again picked over, cleaned, cut into pieces of uniform size, boiled in caustic soda solution for about eight hours, and thoroughly washed. They are then beaten and cut finely with sharp knives, since the absorbency depends largely on the number of cut ends. For the preparation of so-called ashless filter papers for use in quantitative analysis the pulp is treated with hydrochloric or with hydrochloric and hydrofluoric acids. In making the pulp into paper light pressure makes for rapid filtration, but the paper is inclined to pulp up under severe washing. The so-called "hardened" grades of filter paper are the most resistant to washing. For many purposes grey filter papers, which are strengthened with animal fibres, may be employed.

Under the microscope the cotton fibres can easily be recognised by their strap-like appearance and thickened edges, but the treatment to which they have been subjected produces a large number of cut and frayed ends. Some of the fibres may stain with iodine alone (presence of hydroxycellulose), but the majority stain blue with iodine followed by sulphuric acid. They swell evenly and then dissolve in ammoniacal solution of copper oxide and are not stained by picric acid, boiling Millon's reagent, or phloroglucinol and hydrochloric acid.

Grey Filter Papers.—The manufacture of these differs somewhat from that of white filter papers, since they contain animal fibres which would be decomposed if treated with boiling alkali. The rags used also contain some dyed fibres. If a little of the pulped paper be examined in water a small proportion of red, blue, or yellow fibres will usually be observed. On treatment with boiling picric acid solution a few per cent. of the fibres stain yellow and usually show the microscopical appearance of wool. The unstained vegetable fibres usually resemble those found in white filter paper.

Grey filter papers frequently contain iron, which may contaminate the filtrate and in some cases cause colour changes. The use of grey filter papers is further limited by the solubility of wool in alkali and its sulphur content.

JUTE (CORCHORUS)

Source.—Jute consists of the strands of phloem fibres from the stem bark of *Corchorus capsularis*, *C. olitorius*, and other species of *Corchorus* (Fam. Tiliaceæ). These are annual plants about 10 to 12 ft. high which are cultivated in Bengal, in the delta region of the Ganges and Brahmaputra rivers, and in Assam, Bihar, and Orissa.



FIG. 50.—Retting jute stems (from the Imperial Institute Collection).*

Preparation.—The straight stems are cut when, about July, the plants are in flower. The leaves are removed and the stems made into bundles and conveyed to the nearest water tank or pool for *retting*. The bundles are covered with straw to protect

* The above is one of a series of six photographs on the jute industry in India obtainable from the Imperial Institute. The postcards are entitled :—Cutting jute, Retting jute stems, Stripping jute fibre, Sorting jute, Jute bale for export, and Weaving jute at Calcutta. This and similar series on cotton, cocoa, tea, cloves, lac, etc., price 6d. each, are accompanied by a leaflet giving a map and details of the industry.

FIBRES

them from the direct rays of the sun, which would make the fibre specky, and weighted to keep them submerged. The structure of jute bark resembles that of the lime (*Tilia*), with which students of botany will be familiar. The retting process, which lasts about three weeks, is designed to facilitate the separation of the bark from the wood and the strands of phloem fibres from the surrounding softer tissues. Flax and hemp fibres are also prepared by retting. After retting, the worker beats the ends of the stems with a mallet and separates the wood from the fibres. The latter are then cleaned by jerking them backwards and forwards on the surface of the water and hung up in the sun for a few days to dry and bleach. The jute is graded according to colour, glossiness, and length, and pressed into bales each weighing 400 lb. The annual production is

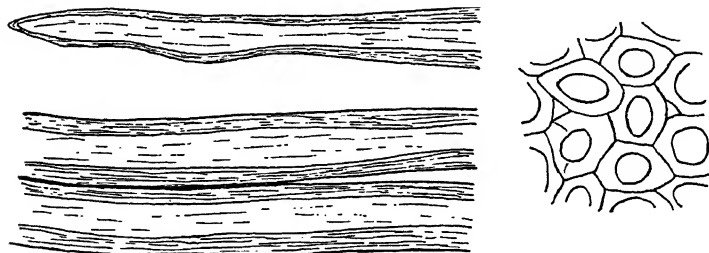


FIG. 51.—Jute fibres, entire and in transverse section.

about 10 million bales. About 60 per cent. of this is spun into yarn in India and made into jute hessian and sacking, jute being the cheapest and most durable material for sacks.

In the preparation of yarns and ropes from jute, hemp, and flax the short fibres are mechanically separated from the long ones, as has been described in the case of cotton. These short fibres are known respectively as jute, hemp, and flax *tows*. In pharmacy, however, the term “tow” is understood to mean the jute tow, *Stupa B.P.C.*, which consists “of jute fibre of good average quality, in cheese rolls.”

Characters.—Jute of the *B.P.C.* is described as “pale buff or silvery-grey” in colour, whilst tow is “yellowish-brown.” The commercial strands of jute are 1 to 3 metres long and about 30 to 140 μ in diameter. Each consists of a bundle of phloem fibres composed of ligno-cellulose. The heavily lignified middle

lamella is destroyed by oxidising agents; a mixture of nitric acid and potassium chlorate may therefore be used to disintegrate the bundles, the individual fibres being then teased

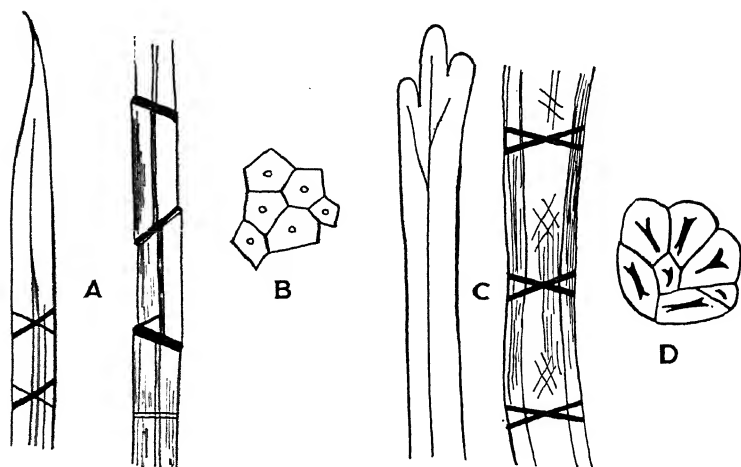


FIG. 52.—A and B, flax fibres; C and D, hemp fibres; B and D, transverse sections. All about $\times 250$. (After von Höhnelt.)

out and sketched. Prepared transverse sections should also be examined and compared with those of hemp and flax. The following notes may be found useful:—

	Jute.	Hemp.	Flax
Source.	<i>Corchorus</i> spp.	<i>Cannabis sativa</i> .	<i>Linum usitatissimum</i> .
Apex	Bluntly pointed or rounded.	Mostly blunt and sometimes forked.	Sharply pointed.
Wall	Without markings; lumen varying in size.	Marked striations, cross fissures, and swellings; lumen large and uniform.	Thick wall with fine cross lines some intersecting; lumen narrow.

	Jute.	Hemp.	Flax.
Source.	<i>Corchorus</i> spp.	<i>Cannabis sativa</i> .	<i>Linum usitatissimum</i> .
Transverse section ..	Polygonal, sharp angles; lumen oval or circular.	Roughly 3 to 6-sided with rounded corners; lumen cleft or branched.	5 or 6 straight sides; point-like lumen.
Diameter	10–25 μ .	16–50 μ .	12–30 μ .
Phloroglucinol Test	Deep red.	Slightly red.	Colourless or slight pink.
Iodine and Sulphuric Acid.	Yellow throughout.	Inner wall blue; middle lamella yellow.	Blue or violet.
Chlorzinciodine ..	Yellow.	Purple to yellow.	Purple to yellow.

Jute should be tested with the above reagents both before and after delignification. When tested with ammoniacal solution of copper oxide the fibres swell considerably, but do not readily dissolve (distinction from cotton and flax).

Standards for Surgical Dressings

Standards for surgical dressings will be found in the *B.P.C.*, which should be consulted. Further information will be found in Chapter LV of Bentley's *Textbook of Pharmaceutics*. The following notes are merely intended to indicate some of the terms employed and the types of standards in use.

Simple Fibres.—The identity of the fibres should be established by microscopical examination and chemical tests, as indicated in the preceding pages. Some or all of the following points may also need examination:—

1. *Moisture-content*, e.g. silk and tow.
2. *Water-soluble extractive*, e.g. cotton wool.
3. *Ash*, e.g. cotton wool.
4. *Absorbency*, e.g. cotton wool and cellulose wadding.

Students should examine a good and a bad sample of cotton wool for the following:—

(a) *Absorbency*.—Compress a weighed sample into a 20-mil beaker and complete the *B.P.C.* test. Compare with non-absorbent cotton wool.

(b) *Foreign Matter and Staple*.—When each sample is pulled over a sheet of paper the bad sample will probably show excess dust, leaf, shell, etc., and will offer less resistance to pulling than the good sample. The length of staple may be judged by pulling fibres straight with forceps on a velvet board and then measuring with a rule. At least a hundred should be measured, and the method is not so accurate as the Baer sorter method.*

(c) *Neps* are small tangled masses of fibres visible to the naked eye. They may be produced during growth or by ginning too fast or whilst the cotton is damp. The two samples should be spread out as described in the *B.P.C.* and the difference in number of neps observed. A sample kept by the Manchester Testing House serves as a standard for this test.

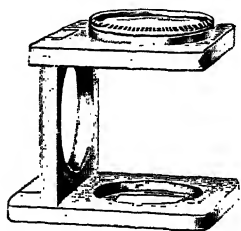


FIG. 53.—A linen tester
(W. Watson & Sons,
Ltd., London).

Fabrics.—The material from which a fabric is made is identified by microscopical examination and chemical tests. As several different materials may be present, a number of threads running in each direction must be examined.

Warp and Weft.—The threads running lengthwise form the *warp*, whilst those crossing them at right angles constitute the *weft*. In fabrics of plain weave the shuttle carrying the weft threads runs over and under alternate warp threads first from left to right and then from right to left. The weft thread thus doubles on itself, giving a *selvage edge*. A fabric usually stretches most in the direction parallel to the weft threads, a fact which serves to distinguish warp from weft if a selvage edge is not present on the piece of material under examination.

For counting the number of threads per linear inch in the warp or weft a linen-tester or linen-prover (Fig. 53) is used. This is opened as shown and placed on the fabric. The sides of the square lying on the material are made of some convenient size (often $\frac{1}{2}$, $\frac{1}{4}$, or 1 in.) and the number of threads in each direction covered by the square can easily be counted by looking through the lens, which is at the correct focal distance. As the material may not be uniform, a series of counts taken in different parts of the fabric should be made.

* Journal Textile Institute, 23, T 35.

Count or Fineness of Yarn.—This is the number of hanks, each of 840 yards in the case of cotton or 560 yards in the case of wool, that make a weight of 1 lb.

It will be observed that the *B.P.C.* lays down standards for the number of threads per linear inch and the weight of a definite area of fabric. Thus, although the count of yarn is only mentioned in a few cases, *e.g.* Open-Wove Bandage, the number of threads and weight per unit area of fabric actually fix the counts of the yarns to be used.

Counts used may be determined by one or other of the following calculations:—

(a) Weigh 12 yards of yarn in grains. Then, since $7,000 \div 840 = 100 \div 12$,

Count = 100 divided by weight of 12 yards in grains.

(b) Cut a sample of fabric to a clear thread and pull out the warp and weft threads separately. Measure their length and weigh them to the nearest tenth of a grain. Then, if

x = length of a thread in inches

N = number of threads

W = total weight of the threads in grains

$$\text{Count} = \frac{7,000}{840} \times \frac{Nx}{36W} = \frac{Nx}{4.32W}$$

Moisture-Content.—In the air-dry state animal fibres average about 12 to 16 per cent. of moisture, whilst vegetable ones contain about 6 to 8 per cent., although they may absorb considerably more. The moisture-content is determined by drying at 100°. The *moisture-regain* is the percentage of moisture required to adjust a dry material to a normal moisture content (cf. Corchorus, *B.P.C.*).

Foreign Matter in Fabrics.—In weaving, starch pastes and other sizes are commonly applied to the warp threads to reduce friction in the loom, whilst a variety of *filling substances* may be used to produce a desired finish. Generally speaking, such additions are undesirable in the case of surgical dressings, which are commonly required to be “free from added foreign matter” or have a specified limit for foreign matter. The determination of foreign matter is described in the *B.P.C.*

Determination of Cotton and Wool.—The determination of the proportion of cotton and wool is necessary in the case of mixed fabrics such as crêpe bandage. The determination depends on the relative solubilities of wool and cotton in a

boiling 5 per cent. sodium hydroxide solution. In such mixed bandages the arrangement of the threads should be noted.

Elasticity.—Bandages such as crêpe and elastic adhesive bandage are, after stretching, required to return to a certain proportion of their fully stretched length.

Miscellaneous Filtering Media

ASBESTOS

Uses and Sources.—Asbestos is used for filtering acids and other corrosive liquids and, in the form of compressed pads, as

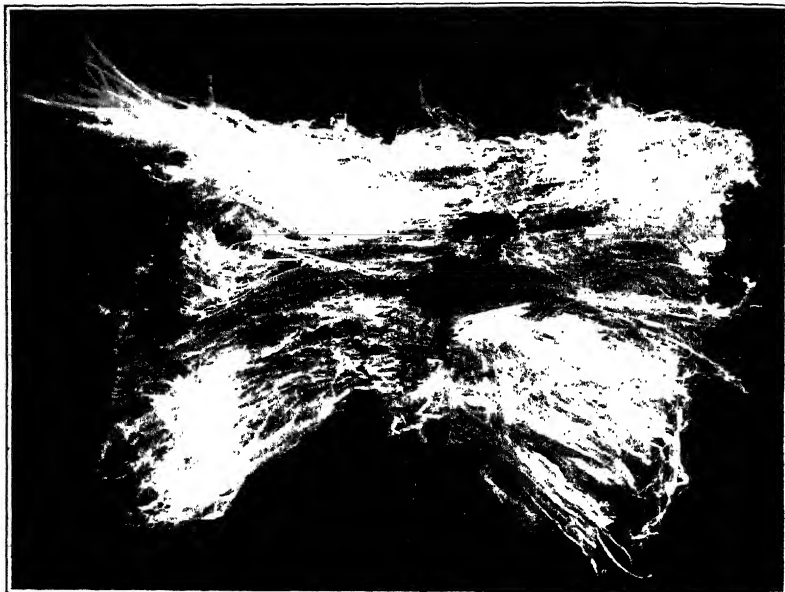


FIG. 54.—Amphibole asbestos (Sutcliffe).

in the Seitz filter, for sterilisation by filtration. Asbestos yarns are used in brake bands and are made into cloths for use in heat-resisting clothing, fireproof curtains, etc. The general term "asbestos" includes the fibrous varieties of the minerals

serpentine (*chrysotile asbestos*) and hornblende (*amphibole asbestos*). Canadian asbestos, a chrysotile variety, is most widely used, but the mineral is also mined in Italy (amphibole variety), Cyprus, South Africa, Australia, and the U.S.S.R. Both varieties consist mainly of hydrated magnesium silicates, but show differences in moisture content, iron content, etc.

Generally speaking, that containing the most water, chrysotile, gives the most silky fibre, and is therefore suitable for spinning; it loses strength when heated above 400° and is attacked by concentrated acids. The amphibole variety, on the other hand, contains less water and cannot readily be spun, but shows little change when heated to $1,100^{\circ}$ and is highly resistant to acids.

Characters.—Rock asbestos may be whitish, yellowish, or greenish, but varies considerably in colour according to its source. It may be easily pulled apart by the fingers and the individual fibres are finer than any vegetable fibres, being 0.5μ or less in diameter.

Asbestos does not fuse when heated (distinction from glass wool) and shows little diminution in weight. Amphibole asbestos is not acted on by concentrated acids, but the chrysotile variety is partly decomposed by hydrochloric acid and, if given sufficient time, completely decomposed by sulphuric acid.

TALC: FRENCH CHALK

Talc resembles asbestos in that it is a native magnesium silicate and in its resistance to heat and reagents. It is used for filtering liquids containing finely divided particles in suspension.

The microscopical appearance is quite different from that of asbestos, since talc consists of crushed crystals the ends of which are jagged and laminating. Like asbestos, it appears bright in polarised light, loses very little weight when ignited, and is resistant to acids and alkalis.

Purified talc is made by boiling the mineral with dilute hydrochloric acid, washing and drying at 110° . When so treated it should contain only a limited amount of water-soluble matter, particularly iron salts, and should be neutral to litmus.

GLASS

Molten glass may be drawn out into very fine threads known as spun glass. The end of a rod of soda glass, about the thickness of a pencil, is melted and drawn to a thread which is thrown over a bicycle wheel, minus the tyre. The end of the glass rod is kept at a suitable temperature and the wheel rotated by a small motor. The glass produced is sold in several forms known as *glass cotton* if in straight fibres, *glass wool* if in masses of curled fibres, and in sheets or pads made from either glass cotton or glass wool. The extra curve on the fibre of glass wool may be obtained by drawing the thread from two glass rods of different degrees of hardness.

Glass is used for filtration in the above forms or in *sintered glass filters*. The latter are made from particles of Jena glass of uniform size. They may be used not only for corrosive liquids but may be sterilised and used for eye-lotions, injections, etc.

Under the microscope the threads of glass wool are seen to be much coarser than those of asbestos, and since they are amorphous they do not shine in polarised light. They fuse on heating but show no immediate change when treated with alkaline solutions or concentrated acids.

DIATOMITE ; PURIFIED SILICEOUS EARTH ; PURIFIED KIESELGUHR

Preparation.—Large deposits of diatomite are found in Aberdeenshire, Virginia, California, Germany, and North Africa. The crude product contains about 65 to 87 per cent. of SiO_2 , together with organic matter, clay, iron oxide, and about 5 to 15 per cent. of water. The silica is mainly amorphous, being present in the siliceous walls of minute, unicellular plants belonging to the Diatomaceæ. A much smaller percentage of silica occurs in the walls of spicules of siliceous sponges and, in a crystalline form, as sand.

The material is dried and crushed, ignited to remove organic matter, boiled with dilute hydrochloric acid to remove impurities such as iron, washed with water, and dried. It is then sifted or "air-blown," the finest grades used in face powders being obtained by the latter method.

Characters.—Purified kieselguhr is a fine, white, or pale-buff odourless powder. It must comply with limit tests for moisture, organic matter, iron, carbonate, and sulphates. For microscopical examination it may be mounted in cresol or olive oil. In the latter medium the amorphous silica of the diatoms becomes almost invisible, whilst the crystalline particles of sand remain clear. Only small amounts of sand (Fig. 55B) should be present.

The diatoms consist of two halves or *valves* which fit together like a pill-box. The two positions from which they may be studied are known as the valve-view and girdle-view. The valves show considerable variation in shape, some samples of kieselguhr showing numerous discoid types resembling that of the *Arachnoidiscus* found in agar (Fig. 62), whilst other samples consist largely of pennate forms (Fig. 55). A mixture of both types is usually most suitable for filtration, and a selection of the best sample of diatomite for a particular task is thus largely dependent on microscopical examination. In many diatoms a median cleft is found in the valves, known as the *raphe*. The valves also show dots and lines which vary in the different species and are due to minute cavities in the wall.

Kieselguhr is insoluble in all acids except hydrofluoric, but is soluble in alkalis. It is used for the filtration of oils, fats, syrups, etc., and in the form of the Berkefeld filter for sterilisation. Diatomite is also employed in face powders, pills, polishing powders, and soaps, and to absorb nitroglycerin in the manufacture of dynamite.

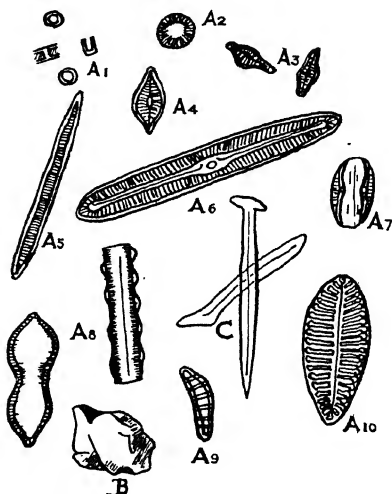


FIG. 55.—Kieselguhr. A1–A10 skeletons of diatoms; B, sand particle; C, sponge spicules. (After Thoms' *Handbuch der Pharmazie*.)

CHALK ; CRETA ; PREPARED CHALK*

Preparation.—Chalk is a whitish or greyish rock which is widely distributed in North-western Europe. It consists mainly of the shells of unicellular animals known as the Foraminifera. Chalk as quarried often contains about 97 or 98 per cent. of calcium carbonate, the remainder being largely siliceous and therefore insoluble in acids. The impure chalk is finely ground with water and freed from most of the heavier siliceous impurities by elutriation. The finer particles constitute the official drug, whilst a somewhat coarser product is sold as "whiting." The elutriated product is allowed to settle and whilst still pasty is poured into a funnel-shaped trochiscator. The latter is tapped on a porous chalk slab and ejects

the chalk to form "cones," which are allowed to dry. These cones may be powdered, but are often asked for under the name of "crab's eyes."

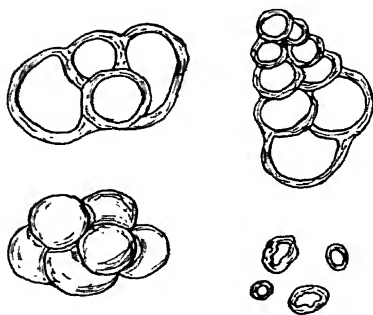


FIG. 56.—Shells from prepared chalk. Left, *Globigerina* in cresol and in water; right, *Textularia* and morpholites in cresol.

Characters.—Chalk should be mounted in cresol, warmed, and examined microscopically. Most of the foraminiferous shells have been broken, but a number of whole ones usually remain. These should be detected with a $\frac{2}{3}$ -in. objective, a higher power being then used for their detailed

study. The whole shells may be concentrated in a small bulk by removing the broken ones by elutriation and examining the residue. The following should be identified and sketched :—

- (a) *Globigerina*.—In these the shell is of calcite and is perforated by large canals. Each consists of a few globular chambers arranged in a plane or helicoid spiral. The size varies from about 35μ to 30μ to 140μ by :

* Although it is convenient to discuss chalk at this point, it must not be regarded as a good filtering medium for pharmaceutical work.

- (b) *Textularia*.—In these the shell is composed of grains of sand cemented together by calcareous matter. They are usually conical or cuneiform in shape and are composed of numerous chambers in two alternating parallel series. The size varies from about 50μ by 40μ to 175μ by 110μ .

- (c) *Morpholites*.—These consist of small, rounded, ovoid or flattened bodies about 10μ to 15μ in diameter.

Prepared chalk and precipitated chalk give the usual chemical tests for calcium and carbonate. When mounted in sulphuric acid (about 50 per cent.) chalks dissolve *with effervescence* (distinction from calcium oxalate) and acicular crystals of calcium sulphate separate on standing.

Precipitated chalk is made by the interaction of a soluble calcium salt and a soluble carbonate. The precipitate varies considerably with the method of preparation. When precipitated at about 0° the product is very light and almost entirely amorphous; and about 30° a denser precipitate or minute rhombohedra is formed, and if boiling solutions are used the precipitate consists of prismatic rhombohedra having a higher specific gravity than either of the previous forms. It will be noted that the official substance is described as microcrystalline powder. Students should, if possible, prepare samples themselves under different conditions and compare their microscopic appearance with that of commercial samples.

CHAPTER XII

QUANTITATIVE MICROSCOPY

IN recent years a considerable number of papers have been published by Wallis and his collaborators on quantitative microscopy. In addition to the simple measurement of the sizes of tissues, cells, and cell contents by means of the micrometer eyepiece or camera lucida (pp. 78 and 79), it is possible to estimate the percentage of foreign organic matter in many powdered drugs by a lycopodium spore method which has been worked out by Wallis and is described in Appendix IX of the *B.P.C.* Other microscopical determinations which may usefully be made in certain cases are vein-islet numbers, palisade ratios, and stomatal numbers.

VEIN-ISLET NUMBERS

The term "vein-islet" is used to denote the minute area of photosynthetic tissue encircled by the ultimate divisions of the conducting strands. The number of vein-islets per sq. mm. is termed the *vein-islet number*. When determined on whole leaves the area examined should be from the central part of the lamina, midway between the margin and midrib. The result should be given to the nearest 0.5.

Method.—Many leaves may be cleared by boiling in chloral hydrate solution in a test-tube placed in a boiling-water-bath. Those which are difficult to clear in this way may, after soaking in water, be treated successively with chlorinated soda to bleach, 10 per cent. hydrochloric acid to remove calcium oxalate, and finally chloral hydrate.

A camera lucida or projection apparatus is set up and by means of a stage micrometer the paper is divided into squares of 1 sq. mm. using a 16-mm. objective. The stage micrometer is then replaced by the cleared preparation and the veins are traced in four contiguous squares, either in a square 2 mm. \times 2 mm. or a rectangle 1 mm. \times 4 mm. (Fig. 57). When counting, it is convenient to number each vein-islet on the

tracing. Each numbered area must be completely enclosed by veins, and those which are incomplete are excluded from the count if cut by the top and left-hand sides of the square or rectangle but included if cut by the other two sides. For example, the vein-islets in Fig. 57 total 62 and the vein-islet number is therefore 15.5.



FIG. 57.—The vein-islets of 4 sq. mm. of the leaf of *Erythroxylum truxillense*. (After Levin.)

Examples.—Levin * determined the vein-islet numbers of a number of species of senna, coca, digitalis, and buchu leaves. As will be seen from the figures given, the vein-islet numbers frequently serve to distinguish closely related plants. In the case of the *Barosma* species it will be noted that *B. serratifolia* and *B. Bathii*, which cannot be distinguished from *B. betulina* by their palisade ratios (see below), are distinguished from the official leaves by their vein-islet numbers.

	Species.	Range of Vein-Islet Numbers.	Average.
(a) Senna ..	<i>Cassia acutifolia</i>	25-29.5	26
	<i>Cassia angustifolia</i>	19.5-22.5	21
(b) Coca ..	<i>Erythroxylum coca</i>	8-12	11
	<i>Erythroxylum truxillense</i>	15-26	20
(c) Digitalis	<i>Digitalis purpurea</i>	2-5.5	3.5
	<i>Digitalis lanata</i>	2-3.5	2.7
	<i>Digitalis lutea</i>	1-1.5	1.2
(d) Buchu ..	<i>Barosma Bathii</i>	15-20	16.8
	<i>Barosma serratifolia</i>	9-24	16.6
	<i>Barosma crenulata</i>	10-16.5	13.0
	<i>Barosma betulina</i>	10-15	12.7
	<i>Barosma pulchella</i>	6-8.5	7.2
	<i>Barosma venusta</i>	5-7	6.0

PALISADE RATIO

The average number of palisade cells beneath each upper epidermal cell is termed the *palisade ratio*. Whereas vein-islet numbers require for their determination fairly large particles, the palisade ratio may be found from quite fine powders.

Method.—Pieces of leaf about 2 mm. square, or powder, are cleared by boiling with chloral hydrate solution, mounted, and examined with a 4-mm. objective. A camera lucida or other projection apparatus is arranged so that the epidermal cells and the palisade cells lying below them may be traced. First a number of groups each of four epidermal cells are traced and their outlines inked in to make them more conspicuous. The palisade cells lying beneath each group are then focused

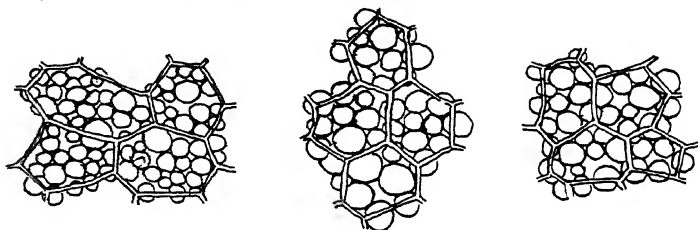


FIG. 58.—Tracings for the determination of palisade ratios. Left to right, *Barosma betulina*, *pulchella*, and *venusta*. (After Wallis and Dewar.)

and traced. The palisade cells in each group are counted, those being included in the count which are more than half covered by the epidermal cells; the figure obtained divided by four gives the palisade ratio of that group. The range of a number of groups from different particles should be recorded.

Examples.—Wallis and Dewar* have investigated the palisade ratios of different species of buchu. The values found serve to distinguish *Barosma pulchella* (6–16), *Barosma venusta* (5–12.5), *Barosma ovata* (5–14.5), and *B. Pegleræ* (6–11.5) from those of the official leaves of *Barosma betulina* (10–26). The palisade ratios of *B. serratifolia*, *B. crenulata*, and *B. Bathii* are, however, approximately the same as that of *B. betulina*.

STOMATAL NUMBER

The average number of stomata per sq. mm. of epidermis is termed the *stomatal number*. In recording results the range as

* Wallis and Dewar, *Buchu and the Leaves of other species of Barosma*, A comparative Study of their Anatomy, *Y.B. Pharm.*, 1933, 347–362.

well as the average value should be recorded for each surface of the leaf and the ratio between the two surfaces.

Method.—Fragments of leaf from the middle of the lamina are cleared with chloral hydrate solution or chlorinated soda. Timmerman counted the number of stomata in from 12 to 30 fields and from a knowledge of the area of the field was able to calculate the stomatal number; the camera lucida method described for vein-islet numbers may also be used, the position of each stoma being indicated on the paper by a small cross.

Examples.—The investigations of Timmerman * indicate that stomatal numbers are usually useless for distinguishing between closely allied species, but that in certain cases the ratio between the number of stomata on the two surfaces may be of diagnostic importance. It is possible, for example, to distinguish *Datura innoxia* from other species of *Datura*, as may be seen from the following figures:—

Species.	Upper Surface.		Lower Surface.		Ratio.
	Range.	Mean.	Range.	Mean.	Lower ÷ Upper.
<i>D. Stramonium</i>	65-140	101	145-240	191	1.97
<i>D. tatula</i> ..	93-175	134	195-331	250	1.98
<i>D. laevis</i> ..	108-115	111	188-215	201	1.80
<i>D. innoxia</i> ..	162-172	167	168-223	196	1.17

LYCOPODIUM SPORE METHODS

Wallis * has shown that lycopodium spores are exceptionally uniform in size (about 25μ) and that 1 milligram of lycopodium contains an average of 94,000 spores. These facts make it possible to evaluate many powdered drugs providing that they contain either (a) well-defined particles which may be counted, e.g. pollen grains or starch grains; or (b) single-layered tissues or cells the area of which may be traced at a definite magnification and the actual area calculated. Whichever method be adopted, mounts containing a definite proportion of the powder and lycopodium are used and the lycopodium spores counted in each of the fields in which the number or area of the particles in the powder is determined. Full practical details for the

* Timmerman, Stomatal Numbers; their Value for Distinguishing Species, *P.J.*, 1927, 118, 241.

† Wallis, *Analyst*, 1916, 357-374.

different types of estimation are described in the *B.P.C.*, which should be read in conjunction with the following notes.

Counting of Particles.—The material is powdered and its moisture-content determined. Weighed quantities of the powder and lycopodium spores are mixed and suspended in a suitable viscous liquid. A drop of this suspension is mounted and examined with a 4-mm. objective. The number of lycopodium spores and the number of characteristic particles, *e.g.* pollen grains, are counted in 25 different fields, which may be obtained by the use of a *mechanical stage* or a *counting-field finder*.* A further series of counts are made from a second mount and a further two series from a second suspension. From the mean of these four results and a knowledge of the weights of lycopodium and powder in the mixture, the number of characteristic particles in 1 milligram of the powder may be calculated.

Examples.—It has been found that a good sample of pyrethrum powder contains from 1,000 to 2,000 pollen grains per milligram and that wheat starch contains about 400 granules per milligram measuring 40μ or more. If either of these powders were adulterated, a determination of the number of pollen grains or larger starch grains respectively would enable the percentage of foreign organic matter contained in each to be determined.

Measurement of Area.—This method is an extension of the above and is applied to powders which contain a characteristic type of particle which varies in size, *e.g.* epidermal fragments of leaves, single layers of sclerenchyma, or isolated fibres. Weighed quantities of the powder and lycopodium spores are mixed as before and may be cleared with chloral hydrate or stained with phloroglucinol and hydrochloric acid to assist identification of the characteristic particles. A camera lucida and drawing board are fitted up and by means of a stage micrometer the magnification produced with a 4-mm. objective is determined as in Example 1, p. 80. A magnification of about 400 is suitable and we will assume that we find the magnification is 420. The cleared or stained suspension is mounted and a suitable area examined. If the particles to be traced are

* Wallis, *Analyst*, 1935, 60, 520. The counting-field finder consists of a card which may be attached to the microscope stage by clips or an adhesive. It has a central hole 1 in. in diameter and is ruled with a rectangle of the size of a microscope slide. Around this are concentric rectilinear frame lines at intervals of 1 and 2 mm. By moving the microscope slide to coincide with each of these in turn the 25 fields are obtained. The positions of these fields are shown in the *B.P.C.*, Fig. 1.

fairly numerous, 25 fields at this magnification will suffice, but if the number of particles is small an area of about 40 sq. mm. should be examined, as in Example 1 below. In each field the spores are counted and the characteristic particles traced. The tracings are cut out, weighed, and their area calculated by weighing a sheet of known area of the paper used. This area divided by the magnification used (420) gives the actual area of the particles in a certain weight of the powdered drug, which can be calculated from the number of spores counted and the weight of spores and powder in the suspension.

Example 1.—Wallis and Saber* find the epidermal areas per gram of dried Indian senna and ailanthus leaves to be 270 sq. cm. and 318 sq. cm. respectively. As the particles of ailanthus are easily distinguished from those of senna, it is possible to determine the percentage of each in a mixture. If the proportion of ailanthus in senna is small, *e.g.* 2 per cent., it is necessary to examine an area of about 40 sq. mm. In one experiment made by Wallis and Saber a mixture containing 2 per cent. of ailanthus was used and duplicate determinations gave 1.73 and 2.15 of ailanthus. For the estimation of such a small percentage an area of 42.6 sq. mm. was examined. This was made up of 9 strips each of width equal to the field of view, *i.e.* 0.385 mm. and 12 mm. long with a semicircular piece at each end equal to half the field.

Example 2.—Similarly it has been shown that the epidermal area per gram of Indian senna stalk is 100 sq. cm. per gram, and the percentage of stalk on a sample of powdered Indian senna may thus be determined.†

Example 3.—Saber‡ has made quantitative determinations of powdered linseed, making use of the fact that this seed contains a well-marked layer of sclerenchyma one cell in thickness. The area per gram of this tissue was found to average 34.3 sq. cm. in material dried at 100° and 49.7 sq. cm. in material which had been defatted and dried. The area per gram in a sample of pressed linseed cake, defatted and dried, was 52.6 sq. cm. It was found possible to determine the percentage of linseed in products such as mixed cattle cake. If the cake contains starch the method is modified to remove this by the preparation of a crude fibre (see p. 116).

* Wallis and Saber, *The Quantitative Determination of Foreign Leaves in Powdered Drugs*, *Y.B. Pharm.*, 1933, 655.

† Saber, *The Determination of Senna Stalk in Senna*, *Y.B. Pharm.*, 1934, 435.

‡ Saber, *The Quantitative Determination of Powdered Linseed*, *Y.B. Pharm.*, 1934, 645.

CHAPTER XIII

THE EXAMINATION, DESCRIPTION, AND MORPHOLOGICAL CLASSIFICATION OF DRUGS

chief means by which drugs are recognised and valued are as follows: examination with the naked eye or a lens, odour, taste, microscopical examination, qualitative and quantitative chemical tests, biological tests, and physical tests. Examples of the last are the determination of specific gravity, melting point, freezing point, boiling point, viscosity, refractive index, and optical rotation.

The monographs in the British and United States Pharmacopœias are arranged in approximately the following order:—

1. **Latin Name and Abbreviation.**

2. **English Name.**

3. **Synonyms.**

4. **Definition:** (a) *Source and Collection.*—The part used, the botanical or zoological source; and in some cases, the commercial variety, time and method of collection, and temperature for drying.

(b) *Purity Rubric.*—When drugs such as cloves, buchu, and the Solanaceous leaves are collected it is not feasible to free completely the organs in question from other parts of the plant. The Pharmacopœias therefore state what percentage of these organs and of other foreign organic matter are officially permitted.

(c) *Percentage of Active Constituents.*

5. **Description.**—Schemes for the description of different plant organs are given below. The official descriptions are arranged in the following order:—

(a) *Macroscopical Characters.*

(b) *Microscopical Characters.*

(c) *Odour and Taste.*

(d) *Solubility.*

6. **Tests for Identity.**—These are usually qualitative chemical tests.

7. **Tests for Purity.**—(a) *Physical*, e.g. the S.G. of copaiba.

(b) *Microscopical*, e.g. absence of calcium oxalate and sclerenchyma from digitalis leaves.

(c) *Chemical*, e.g. absence of starch and tannin from acacia.

8. **Assay**, e.g. for alkaloids in belladonna leaf or for balsamic esters in balsam of Peru.

9. **Storage Directions.**

10. **Preparations** in which the drug is used.

11. **Dose.**

Directions for Practical Work.—Every drug examined should be studied systematically and a report written in a regular order. Sketches should be made wherever possible. These should be of large size and to scale. The work may be arranged under the heading 1 to 7 given above. Under heading 5 the description should be arranged in a regular sequence for each type of organ, *e.g.* leaf, bark, etc., so that nothing of importance is missed. Providing that some regular order is adopted it is unnecessary to adhere rigidly to the following schemes or to copy into the notebook the numerous headings. Important commercial varieties, substitutes, and adulterants should be examined in a similar way. A certain number of botanical terms are necessary to give the descriptions precision. The more important of these are given below.

Leaves and Tops ("Herbs")

Aerial Stem.—Size; herbaceous or woody, upright or creeping; shape; colour; smooth, ridged, hairy; if hairs are present say whether glandular or not; arrangement of tissues as seen in transverse section.

Position and Arrangement of Leaves.—*Radical* (arising from the crown of the root) or *cauline* (arising from the aerial stem). In the Solanaceæ note *adnation* (the fusion of part of the leaf with the stem). The arrangement may be *alternate*, *e.g.* lobelia, *opposite*, *decussate* (in pairs alternately at right angles, *e.g.* peppermint), or *whorled*.

Leaves, Flowers, and Fruits, when present, should be described according to the following schedules.

Important Leaves and Tops

Savin . . .	S.* See p. 216.
Indian Hemp	S., U.S.P. See p. 300.
Peppermint	U.S.P. See p. 570.
Spearmint	U.S.P. See p. 571.
Stramonium	B.P., U.S.P. See p. 572.
Hyoscyamus	B.P., U.S.P. See p. 577.
Belladonna	B.P., U.S.P. See p. 581.
Lobelia	B.P. See p. 626.

* Drugs marked S. are unofficial, but are included in the examination syllabus of the Pharmaceutical Society of Great Britain. Those marked B.P. are included in the British Pharmacopœia, 1932, and those marked U.S.P. in the U.S.P. XI (1936).

Leaves or Leaflets

Duration.—*Deciduous* or *evergreen*.

Leaf Base.—*Stipulate* or *exstipulate*; if stipulate describe shape, etc.; if sheath is present describe it, e.g. *amplexicaul* (stem-clasping).

Petiole.—Petiolate or sessile. If present, describe size, shape, colour, hairs, etc.

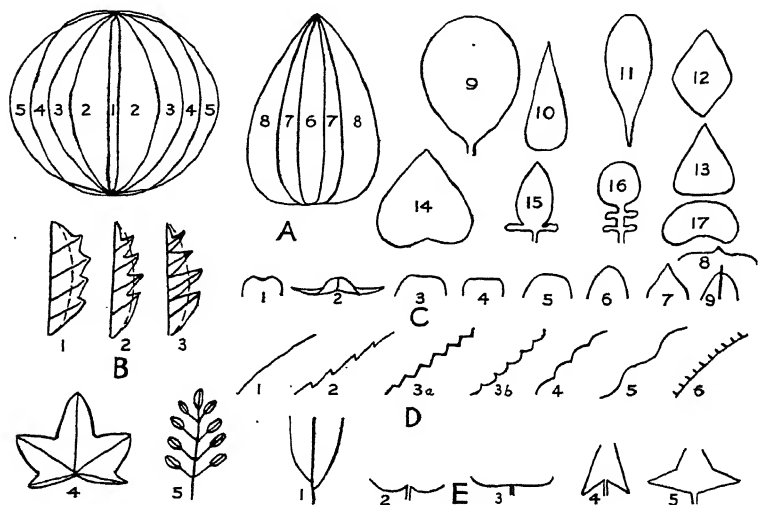


FIG. 59.—Terms applied to leaves. A. *Shape*: 1, acicular; 2, elliptical; 3, oval; 4, oblong; 5, round; 6, linear; 7, lanceolate; 8, ovate; 9, obovate; 10, subulate; 11, spatulate; 12, diamond-shaped; 13, cuneate; 14, cordate; 15, auriculate; 16, lyrate; 17, reniform. B. *Composition and Incision*: 1, pinnatifid; 2, pinnatipartite; 3, pinnatisect; 4, palmatifid; 5, imparipinnate. C. *Apex*: 1, emarginate; 2, recurved; 3, retuse; 4, truncate; 5, obtuse; 6, acute; 7, acuminate; 8, mucronate; 9, apiculate. D. *Margin*: 1, entire; 2, serrate; 3a and 3b, dentate; 4, crenate; 5, sinuate; 6, ciliate. E. *Base*: 1, asymmetric; 2, cordate; 3, reniform; 4, sagittate; 5, hastate.

Lamina: 1. **Composition.**—If simple, whether *pinnate* or *palmate*. If compound, whether *paripinnate* (with an equal number of leaflets) or *imparipinnate* (Fig. 59).

2. **Incision.**—The leaf may be more or less cleft, the amount being indicated by adding *-fid*, *-partite*, or *-sect* to a prefix denoting whether the leaf is of a pinnate or palmate type.

3. **Shape.**—If the shape is obscured by drying, soak the leaf in warm water and spread it on a tile. The shape may be *acicular*, *elliptical*, *oval*, *oblong*, *round* or *orbicular*, *linear*, *lanceolate* or *ovate*; or if the petiole is attached at the narrower end *obovate*, etc.; *subulate* (awl-shaped), *spatulate* (spoon-shaped), *cuneate* (wedge-shaped), *lyrate*, *hastate*, *sagittate*, *auriculate*, *cordate*, or *reniform* (kidney-shaped).

4. **Venation.**—*Parallel*, *pinnate* (feather-like), *palmate*, *reticulate* (net-veined).

5. **Margin.**—*Entire*, *serrate*, *dentate*, *crenate*, *sinuate*. Presence or absence of marginal hairs or of water pores (*hydrathodes*).

6. **Apex.**—*Emarginate*, *recurved*, *retuse*, *truncate*, *obtuse*, *acute*, *acuminate*, *mucronate*, *apiculate*.

7. **Base.**—Symmetrical or asymmetrical; *cordate*, *reniform*, etc.

8. **Surface.**—Colour; glabrous (free from hairs) or pubescent (hairy); if the latter, whether hispid (with rough hairs), hirsute (with long distinct hairs) or with glandular hairs; punctate (dotted with oil glands). Note lines on surface of coca leaves, raised points on belladonna, press marks on Tinnevely senna, etc. Note any differences between the upper and lower surface, making surface preparations as indicated on p. 92.

9. **Texture.**—Brittle, coriaceous, papery, fleshy, etc.

10. **Calcium Oxalate.**—A small piece of the leaf should be cleared by warming in chloral hydrate solution and examined for calcium oxalate.

Other Organs and Percentage Purity.—For example, the stems and fruits found in buchu should be sketched and described. A weighed quantity of drug may be separated into leaves, stems, fruits, etc. The different organs are then weighed and their percentage calculated and compared with the official requirements.

Important Leaves or Leaflets

Coca ..	S. See p. 414.
Buchu ..	B.P. See p. 421.
Hamamelis	B.P. See p. 453.
Senna ..	B.P., U.S.P. See p. 495.
Eriodictyon	U.S.P. See p. 566.
Digitalis ..	B.P., U.S.P. See p. 592.

Inflorescences and Flowers

Type of Inflorescence.—*Racemose*, *cymose* or mixed (e.g. racemes of cymes in clove).

Axis or Receptacle of Inflorescence.—The main axis of an inflorescence is called the *rachis* while the branches bearing flower clusters and individual flowers are termed *peduncles* and *pedicels* respectively. The term *receptacle of the inflorescence* must not be confused with the receptacle of the flower (see below). In the Roman chamomile the receptacle of the inflorescence is conical and solid, a membranous palea subtends each floret and the capitulum is surrounded by an involucre of bracts. Describe colour, shape, etc., of bracts.

Type of Flower.—Monocotyledon or dicotyledon. Unisexual or hermaphrodite. Regular or zygomorphic. Hypogynous, perigynous, or epigynous (see Fig. 60).

Receptacle of the Flower (Thalamus or Torus) is the extremity of the peduncle on which the calyx, corolla, etc., are inserted. When the receptacle is elongated below the calyx it is called a *hypanthium* or if below the ovary a *gynophore* or stalk of the ovary (Cf. clove).

Calyx.—Number of sepals if *polysepalous* or divisions if *gamosepalous*. *Caducous* (e.g. poppy) or *persistent* (e.g. belladonna). Describe colour, shape, hairs, etc., as for a leaf.

Corolla.—Number of petals if *polypetalous* or divisions if *gamopetalous*. Describe as for leaves noting any special characteristics such as the venation in henbane and the oil glands in clove petals.

Andrœcium.—Number of stamens; whether free or joined (*mon-*, *di-*adelphous, etc.), *didynamous* or *tetradynamous*, *epipe-talous*, etc. Dehiscence of anthers (valves, pores, or slits).

Gynœcium.—Number of carpels; apocarpous or syncarpous; superior or inferior. Sizes and shapes of stigma, style, and ovary. The enlargement at the base of the styles in the Umbelliferae is called a *stylopod*. Number of loculi, placentation (parietal, axile, free-central, etc.).

Ovules.—Number in each loculus. Straight (*orthotropous*), incurved (*campylotropous*), inverted (*anatropous*) (Fig. 60).

Important Inflorescence and Flower

Cloves	..	..	..	B.P., U.S.P.	See p. 511.
Chamomiles	..	..	..	S.	See p. 630.

Also flowers of cannabis, stramonium, henbane, and belladonna, and the calices and pedicels of capsicum, etc.

Fruits

The following classification shows the principal types of fruit met with in pharmacognosy :—

A. *Simple*, i.e. formed from a gynoecium with one pistil.

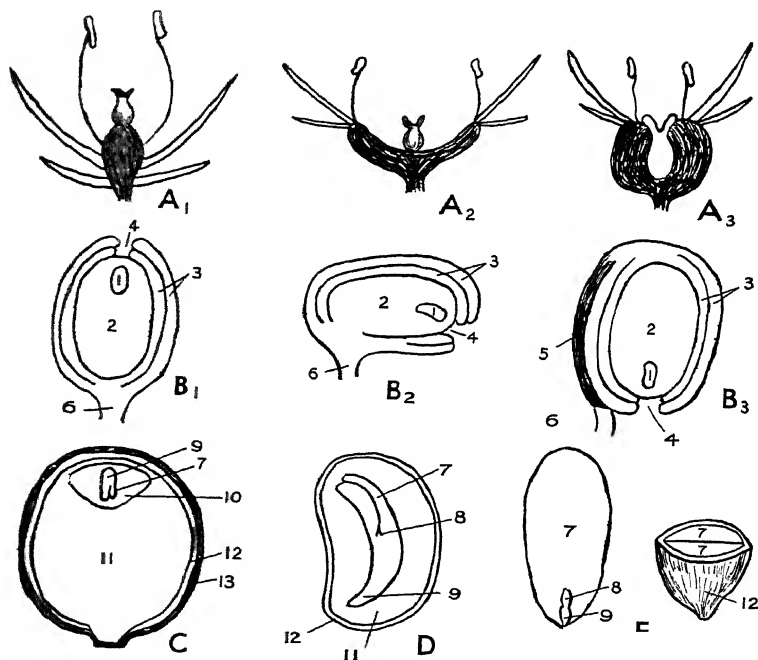


FIG. 60.—A₁, A₂, and A₃ hypogynous, perigynous, and epigynous flowers; B₁, B₂, and B₃ atropous, campylotropous, and anatropous ovules; C, fruit of *Piper* with single albuminous seed; D, albuminous seed of *Papaver*; E, exalbuminous seed of almond. 1, embryo sac; 2, nucellus; 3, integuments; 4, micropyle; 5, raphe; 6, funicle; 7, cotyledon; 8, plumule; 9, radicle; 10, perisperm; 11, endosperm; 12, testa; 13, pericarp.

B. *Aggregate*, i.e. formed from more than one pistil, e.g. aconite.

C. *Collective*, i.e. formed not from one flower but from an inflorescence, e.g. fig.

I. Simple, Dry, Indehiscent Fruits.—(a) *Achene*. A small hard indehiscent fruit. The term is strictly only applied to those formed from one carpel, but is sometimes used for those formed from two carpels, *e.g.* the fruit of the Compositæ. The latter is better termed a *cypsela*.

(b) *Nut*.—This is similar to an achene, but is typically formed from two or three carpels, *e.g.* dock fruit.

(c) *Caryopsis*.—This is the type of fruit in which the testa and pericarp are fused (found in the cereals).

II. Simple, Dry, Dehiscent Fruits.—(a) *Legume*. A fruit formed from one carpel which splits along both dorsal and ventral sutures, *e.g.* senna.

(b) *Follicle*.—A fruit formed from one carpel which dehisces by the inner suture only. Follicles are usually found in aggregates or *etærios*, *e.g.* aconite and *strophanthus*.

(c) *Capsules* are dry dehiscent fruits formed from two or more carpels. Some bear special names, *e.g.* the *siliqua* and *silicula* found in the Cruciferae, and the *pyxis* or *pyxidium* found in henbane. The latter is a capsule which opens like a pill-box by means of a lid.

III. Schizocarpic or Splitting Fruits.—A familiar example of this group is the *cremocarp*, the bicarpellary fruit of the Umbelliferae, which splits into two *mericarps*.

IV. Succulent Fruits.—(a) *Drupe*. This is typically formed from one superior carpel, *e.g.* almond and nutmeg. The inner part of the pericarp, which is called the endocarp, is hard and woody and encloses one seed.

(b) *Berry*.—This fruit is formed from one or more carpels and the pericarp is entirely fleshy. It is usually many-seeded. Examples: *nux-vomica*, *colocynth*, orange, lemon, *capsicum*. Special terms which are sometimes used are *pepo* for the berry of the Cucurbitaceae and *hesperidium* for that of the orange and similar Rutaceous fruits.

The description of a fruit may be arranged as follows:—

Class.—See above.

Shape and Dimensions.

Adhesion.—Superior or inferior. Fruits formed from inferior ovaries usually show floral remains at the apex, *e.g.* cardamom, fennel, unpeeled *colocynth*, and *lobelia*.

Dehiscence.—Dehiscent or indehiscent. Different types of dehiscence are shown by the legume, follicle, *siliqua*, and the *pyxidium* and other capsules. Most capsules split longitudinally into valves which are usually equal or double in number

to those of the loculi or placentæ. Dehiscence is termed *septicidal* if the valves separate at the line of junction of the carpels or *loculicidal* if the valves separate between the placentæ or dissepiment. In the latter case the placentæ or dissepiment may remain attached either to the axis or to the valves.

Pericarp.—Colour, texture, markings, number of sutures. Note whether uniform throughout or modified into epicarp, mesocarp, and endocarp.

Placentation, e.g. marginal in senna, parietal in poppy, axile in cardamom, etc.

Seeds.—Number. Describe in detail (see below).

Other Characters.—Odour, taste, food reserves.

Important Fruits or Parts of Fruits

Colocynth	B.P. See p. 392.
Orange Peel	B.P. See p. 428.
Lemon Peel	B.P., U.S.P. See p. 431.
Senna Fruits	B.P. See p. 499.
Tamarinds	B.P. See p. 502.
Fennel ..	B.P. See p. 520.
Coriander	B.P. See p. 524.
Caraway ..	B.P., U.S.P. See p. 526.
Dill ..	B.P. See p. 528.
Capsicum	B.P., U.S.P. See p. 587.

Seeds

Seeds may be produced from orthotropous, campylo-tropous, or anatropous ovules (Fig. 60). Care must be taken to distinguish seeds from fruits or parts of fruits containing a single seed, e.g. cereals and the mericarps of the Umbelliferae. The seed consists of a kernel surrounded by one, two, or three seed coats. Most seeds have two seed coats, an outer *testa* and an inner *tegmen*. The seed is attached to the placenta by a stalk or *funicle*. The *hilum* is the scar left on the seed where it separates from the funicle. The *raphe* is a ridge of fibrovascular tissue formed in more or less anatropous ovules by the adhesion of funicle and testa. The *micropyle* is the opening in the seed coats which usually marks the position of the radicle. An expansion of the funicle or placenta extending over the surface of the seed like a bag is known as an *aril* or *arillus*. A false aril or *arillode* resembles an aril, but is a seed coat. A *caruncle* or *strophiole* is a protuberance arising from the testa near the hilum.

The kernel may consist of the embryo plant only (*exal-*

buminous seeds), or of the embryo surrounded by *endosperm* or *perisperm* or both (*albuminous seeds*) (Fig. 60). Endosperm and perisperm are tissues containing food reserves and are formed respectively inside and outside the embryo sac.

The description of a seed may be arranged as follows :—

Size, Shape, and Colour.

Funicle, etc.—Describe funicle and, if present, raphe and aril.

Hilum and Micropyle.—Size and positions.

Seed Coats.—Number. If present, describe arillode, caruncle, or strophiole.

Thickness and texture of testa ; whether uniform in colour or not ; smooth, pitted, or reticulate. If hairs are present describe their length, texture, and arrangement. Mechanism for dispersal, *e.g.* awn of strophanthus.

Perisperm.—Present or absent. Nature of food reserves.

Endosperm.—Present or absent. Nature of food reserves.

Embryo.—Size and position, *e.g.* straight in strophanthus, curved in stramonium, folded in mustard. Size, shape, number, and venation of cotyledons. Size and shape of radicle.

Odour and Taste.

Important Seeds

Colchicum	B.P., U.S.P. See p. 237.
Cardamom	B.P., U.S.P. See p. 273.
Nutmeg ..	B.P., U.S.P. See p. 330.
Black Mustard	U.S.P. See p. 386.
Linseed ..	B.P., U.S.P. See p. 412.
Nux Vomica	B.P., U.S.P. See p. 546.
Strophanthus	B.P. See p. 555.

Woods

Although few drugs consist solely of wood no description of a stem or root is complete without an account of its wood. Wood consists of the secondary tissues produced by the cambium on its inner surface. The cells composing these tissues, the vessels, tracheids, wood fibres, and parenchyma, are not necessarily all lignified. In some cases, *e.g.* the wood of belladonna root (Fig. 200), non-lignified elements predominate. The distribution of the lignified elements may be ascertained by treating smoothed transverse, radial, and tangential surfaces or sections with phloroglucinol and hydrochloric acid. In trees the cells of the old wood frequently become coloured as they fill with waste products such as

resins, tannins, and colouring matters. This central region is called the *heartwood*, whilst the outer wood, which still retains its normal appearance and functions, is called the *sapwood*. Commercial guaiacum wood and logwood consist of heartwood.

In transverse section woods usually show annual rings each of which normally represents a season's growth. In some tropical species the annual rings are not well marked owing to the absence of a seasonal interruption in growth. The so-called *false annual rings* found, for example, in quassia are irregular rings formed by alternating zones of wood parenchyma and fibres. The width and height of *medullary rays* are of diagnostic importance in the case of Jamaica and Surinam quassias (p. 439) and rhubarbs (p. 310). The *grain* of wood is due primarily to the arrangement of the annual rings and medullary rays, but is modified by the wavy course of the wood elements, which causes the wood to split irregularly. Irregular splitting is largely dependent on the number of lateral branches which cause knots in the wood.

Woods may be described under the following headings:—

Size and Colour.—Note any differentiation into sapwood and heartwood. The latter may not be coloured uniformly, e.g. logwood.

Specific Gravity.—Woods vary considerably in this respect, e.g. guaiacum has a S.G. of 1.33 and poplar one of 0.38.

Hardness and Behaviour when Split.

Transverse Surface.—The arrangement of the lignified elements may be markedly radiate or they may be irregularly scattered. Note distribution of wood fibres and wood parenchyma, and of true and false annual rings. Measure the distances between medullary rays and between annual rings.

Longitudinal Surfaces.—Measure height of medullary rays.

Odour and Taste.

Important Wood

Quassia B.P. See p. 438.

Examples of the differences met with in wood structure may be seen in rhubarb (Fig. 98), aconite (Fig. 115), podophyllum (Fig. 121), calumba (Fig. 123), quassia (Fig. 146), senega (Fig. 148), liquorice (Fig. 158), gentian (Fig. 191), jalap (Fig. 193), belladonna (Fig. 200), and ipécacuanha (Fig. 210).

Barks

Barks, as understood in commerce, consist of all tissues outside the cambium. In botany the term "bark" is sometimes restricted to the "outer bark," *i.e.* the periderm and all tissues lying outside it. A young bark is composed of the following tissues :—

(a) *Epidermis*, a layer of closely-fitting cuticularised cells with occasional stomata.

(b) *Primary Cortex*, a zone usually consisting of chlorophyll-containing collenchyma and parenchyma.

(c) *Endodermis* or inner layer of the cortex, which frequently contains starch.

(d) *Pericycle*, which may be composed of parenchyma or of fibres. Groups of fibres often occur opposite each group of phloem.

(e) *Phloem*.—This consists of sieve tubes, companion cells, and phloem parenchyma separated by radially-arranged medullary rays.

In commercial barks the above structures have been modified by the activity of the cambium and the cork cambium or *phellogen*. Growth of the new tissues produced by the cambium causes the tissues of the primary bark to be tangentially stretched, compressed, or torn. As these cells are stretched tangentially they may be divided by radial walls, *e.g.* in the medullary rays. During this *dilation* groups of parenchymatous cells in the cortex and phloem may be thickened into sclerenchymatous cells. The cambium produces secondary phloem, which often consists of alternating zones of soft bast and bast fibres. The pericycle is frequently ruptured and parenchymatous cells which grow into the spaces may develop into sclerenchyma.

The cork cambium or *phellogen* may arise in the epidermis (*e.g.* willow), primary cortex, or pericycle. The phellogen produces on its outer side *cork*, and on its inner side chlorophyll-containing unsuberised cells which form the *secondary cortex* or *phelloderm*. These three layers are known as the *periderm*. If the cork cambium develops in or near the pericycle, a part or the whole of the primary cortex will lie outside the cork and will be gradually thrown off. *Lenticels* replace stomata for purposes of gaseous exchange, and as the cork increases the amount of chlorophyll-containing tissue decreases.

The natural curvature of the bark increases when the bark

is removed from the tree and dried. Large pieces of trunk bark, especially if subjected to pressure, may be nearly flat. Terms used to describe the curvature are illustrated in Fig. 61. Some commercial barks, e.g. cinnamon and quillaia, consist of the inner bark only. In quillaia the dark patches often found on the outer surface are known as *rhytidome* (literally, a wrinkle). This term is applied to plates of tissue formed in the inner bark.

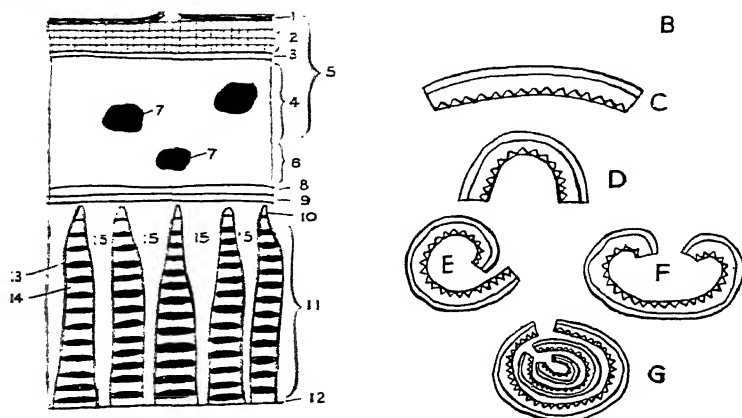


FIG. 61.—Barks. A. Diagram showing a typical arrangement of the tissues. 1, outer surface frequently showing lichens lenticels, and remains of primary tissues cut off by the cork; 2, cork; 3, cork cambium or phellogen; 4, phelloderm or secondary cortex; 5, periderm; 6, inner part of primary cortex; 7, groups of cortical sclerenchyma; 8, endodermis; 9, pericycle; 10, primary phloem; 11, secondary phloem; 12, cambium; 13, hard bast; 14, soft bast; 15, medullary rays. B—G, Shapes of Barks: B, flat; C, curved; D, channelled; E, single quill; F, double quill; G, compound quill.

Barks may be described under the following headings:—

Origin and Preparation.—From trunk, branches, or roots. Whole bark or of inner part only.

Size and Shape.

Outer Surface.—Lichens, mosses, lenticels, cracks or furrows, colour before and after scraping.

Inner Surface.—Colour, striations, furrows.

Fracture.—Short, fibrous, splintery, granular, etc. The fracture depends largely on the number and distribution of

stone cells and fibres. A bark frequently breaks with a short fracture in the outer part and a fibrous fracture in the phloem.

Transverse Surface.—A smoothed transverse surface, especially if stained with phloroglucinol and hydrochloric acid, will usually show the general arrangement of the lignified elements, medullary rays, and cork. Sections, however, take little time to cut and are more satisfactory. A microscopical examination for calcium oxalate can then be made.

Odour and Taste.

Important Barks

Cinnamon (Ceylon)	B.P. See p. 336.
Cinnamon (Saigon)	U.S.P. See p. 344.
Cascara	B.P., U.S.P. See p. 447.
Virginian Prune..	B.P., U.S.P. See p. 459.
Quillaia	B.P. See p. 463.
Cinchona.. ..	B.P., U.S.P. See p. 600.

Subterranean Organs

Under this heading it will be convenient to discuss : (*a*) stem structures such as corms, bulbs, stem-tubers, and rhizomes ; and (*b*) root structures such as true and adventitious roots and root-tubers. It must be remembered that many drugs which are commonly spoken of as roots consist wholly or partly of rhizomes, *e.g.* rhubarb and gentian, and that in many cases the gradual transition from stem to root makes an accurate differentiation of the two parts impossible.

Monocotyledonous rhizomes can be distinguished from dicotyledonous rhizomes by the scattered arrangement of their vascular bundles. Stem structures may usually be distinguished from roots by the fact that they bear buds and possess a well-marked pith. In underground organs chlorophyll is absent, and starch, when present, is usually abundant and in the form of large grains of reserve starch. If the drug has been too strongly heated the starch may be gelatinised.

The following scheme may be used with suitable modifications for the description of most subterranean organs :—

Morphological Nature.—Rhizome, root, etc.

Condition.—Fresh or dry ; whole or sliced ; peeled or unpeeled.

Subaerial Stems.—Remains of subaerial stems occur in aconite, serpentary, etc. Note their number, leaf remains, and whether present in sufficient amount to constitute an adulteration.

Subterranean Stems : 1. Size and Shape.

2. Direction of Growth and Branching.

3. Surface Characters.—Colour, stem scars, buds, cataphyllary leaves, roots or root scars, lenticels, cracks, wrinkles, surface crystals, evidence of insect attack, peeling, etc.

4. Fracture and Texture.—Flexible, brittle, hard, horny, mealy, splintery, etc.

5. Transverse Section.—Colour (cf. male fern) ; distribution of lignified and secretory elements, *e.g.* in ginger ; relative sizes of bark, wood, and pith. Note any abnormalities such as the star spots and absence of a lignin reaction in rhubarb.

Roots : 1. Kind.—True, *i.e.* developed from the radicle or its branches, or adventitious.

2. Size and Shape.—Tuberous, conical, cylindrical, etc.

3. Surface Characters.—Colour ; cracks, wrinkles, annulations, lenticels, etc.

4. Fracture and Texture.

5. Transverse Section.—Note absence of pith, whether the wood is markedly radiate or not, and any abnormalities such as are found in jalap and senega.

Food Reserves and Chemical Tests.

Odour and Taste.

Important Subterranean Organs

As mentioned above, a complete differentiation of underground organs into stem and root structures is not practicable. The following grouping, although somewhat arbitrary, may be useful :—

A. Corm, Bulb, or Rhizome

Colchicum Corm	..	B.P.	See p. 236.
Squill Bulb	..	B.P., U.S.P.	See p. 249.
Ginger Rhizome	..	B.P., U.S.P.	See p. 265.

B. Rhizome and Roots

Male Fern	..	B.P., U.S.P.	See p. 195.
Veratrum	..	U.S.P.	See p. 232.
Serpentary	..	B.P., U.S.P.	See p. 308.
Rhubarb	..	B.P., U.S.P.	See p. 310.
Podophyllum	..	B.P., U.S.P.	See p. 362.
Indian Podophyllum	..	B.P.	See p. 365.
Liquorice	..	B.P., U.S.P.	See p. 470.
Gentian	..	B.P., U.S.P.	See p. 551.
Ipecacuanha	..	B.P., U.S.P.	See p. 609.
Valerian	..	B.P., U.S.P.	See p. 622.

C. Roots

Sarsaparilla	..	..	U.S.P.	See p. 253.
Aconite	..	..	B.P., U.S.P.	See p. 348
Calumba	..	..	B.P.	See p. 367.
Althæa	..	..	U.S.P.	See p. 399.
Senega	..	..	B.P.	See p. 443.
Krameria	..	..	B.P.	See p. 505.
Jalap	..	..	B.P.	See p. 560.
Ipomœa	..	..	B.P.	See p. 563.
Belladonna	..	..	B.P., U.S.P.	See p. 584.

Unorganised Drugs

In Chapter III many of the types of unorganised drugs are discussed, namely, fixed oils, fats, and waxes (pp. 33-41); volatile oils (pp. 41-43); resins, oleo-resins, oleo-gum-resins, balsams, and gums (pp. 43-44). To these must be added dried juices (*e.g.* aloes), latices (*e.g.* opium), and extracts (*e.g.* agar and catechu). The following scheme may be used:—

Physical State.—Solid, semi-solid, or liquid.

A. If Solid: (a) **Size and Form.**—Tears, lumps, etc., and their approximate size and weight.

(b) **Packing.**—Paper, skins, leaves, etc.

(c) **External Appearance.**—Colour; shiny or dusty; opaque or translucent; presence of vegetable fragments.

(d) **Hardness and Fracture.**—Conchoidal, porous, etc.

(e) **Solubility** in water and organic solvents.

(f) **Vegetable Debris**, if any, remaining insoluble, *e.g.* in myrrh and asafetida.

(g) **Effect of Heat.**—Does substance melt, char, sublime, or burn without leaving appreciable ash.

(h) **Microscopical Appearance** of powder, sublimate (*e.g.* balsams), or insoluble matter (*e.g.* opium and catechu).

B. If Liquid: (a) **Colour and Fluorescence.** See Chapter XXV.

(b) **Viscosity.**

(c) **Density.**

(d) **Solubility**, *e.g.* of balsam of Peru in a solution of chloral hydrate. Also the behaviour of the solution, *e.g.* of copaiba in petroleum spirit, on the further addition of solvent.

Odour and Taste.

Chemical Tests.

Important Unorganised Drugs

A. Fixed Oils	..	Castor Oil	..	B.P., U.S.P.	See pp. 38 and 406.
		Olive Oil	..	B.P., U.S.P.	See p. 543.
		Cod Liver Oil	..	B.P., U.S.P.	See p. 655.
B. Fats and Waxes		Beeswax	..	B.P., U.S.P.	See p. 649.
		Spermaceti	..	U.S.P.	See p. 659.
		Lard	..	B.P., U.S.P.	See p. 660.
		Wool Fat	..	B.P., U.S.P.	See p. 661.
C. Volatile Oils	..	Oil of Cade	..	B.P., U.S.P.	See p. 218.
		Oil of Cloves	..	B.P., U.S.P.	See pp. 41 and 514.
D. Resin	..	Colophony	..	B.P., U.S.P.	See p. 205.
E. Oleo-Resin	..	Copaiba	..	B.P., U.S.P.	See p. 506.
F. Oleo-Gum-Resins		Myrrh	..	B.P., U.S.P.	See p. 440.
		Asafetida	..	B.P., U.S.P.	See p. 531.
G. Balsams	..	Styrax	..	B.P., U.S.P.	See p. 455.
		Balsam of Tolu	..	B.P., U.S.P.	See p. 480.
		Balsam of Peru	..	B.P., U.S.P.	See p. 482.
		Benzoin	..	B.P., U.S.P.	See p. 539.
H. Gums	..	Tragacanth	..	B.P., U.S.P.	See p. 484.
		Acacia	..	B.P., U.S.P.	See p. 491.
I. Extracts	..	Agar	..	B.P., U.S.P.	See p. 182.
		Catechu	..	B.P.	See p. 615.
		Gelatin	..	B.P., U.S.P.	See p. 662.
J. Dried Latex	..	Opium	..	B.P., U.S.P.	See p. 373.
K. Dried Juices	..	Aloes	..	B.P., U.S.P.	See p. 238.
		Kino	..	U.S.P.	See p. 478.
L. Saccharine Substance	..	Honey	..	B.P., U.S.P.	See p. 648.
M. Tar	..	Wood Tar	..	B.P., U.S.P.	See p. 208.

Miscellaneous Vegetable Products

Ergot	..	..	B.P., U.S.P.	See p. 187.
Lycopodium	..	..	U.S.P.	See p. 199.
Maize Starch	..	..	B.P., U.S.P.	See p. 89.
Galls	..	..	U.S.P.	See p. 292.
Camphor	..	..	B.P., U.S.P.	See p. 346.
Cotton	..	..	S., U.S.P.	See p. 129.
Chrysarobin	..	..	B.P., U.S.P.	See p. 479.

CHAPTER XIV

THE BOTANICAL CLASSIFICATION OF DRUGS

Botanical Systems of Classifications.—Before the widespread acceptance of the principle of evolution, biologists, being convinced of the fixity of species and lacking much of the information we now possess, confined themselves to more or less artificial methods of classification, their systems being frequently based on one or a few characters instead of upon the organism as a whole. The system of Bentham and Hooker, elaborated in the *Genera Plantarum* (1862-1883), is largely artificial, but, as natural systems are being continually altered and improved as knowledge increases, it has been found convenient to retain this system as a basis in such works as the *British Flora*, and for museum collection such as the herbaria of Kew and the British Museum.

Of the more strictly phylogenetic systems may be mentioned that of Engler and Prantl used in *Die naturliche Pflanzenfamilien*, and that of Hutchinson.* The arrangement of the families of flowering plants used in the present book is that of Rendle,† and is described by him as "a conservative one, following in the main that of Engler but without claiming to be strictly phylogenetic."

Subdivisions of the Phyla.—The branches of the genealogical tree differ so much in size that it is not easy to decide which are of equal systematic importance and what one biologist may consider as a family ‡ another may regard as a subfamily. Similarly, the species of one botanist may be

* See *The Families of Flowering Plants*, 1, "Dicotyledons" (1926); 2, "Monocotyledons" (1934).

† *The Classification of Flowering Plants*. Vol. 1, *Gymnosperms and Monocotyledons* (1930); Vol. 2, *Dicotyledons* (1925). The introductions of the above works contain historical and comparative accounts of plant classification, and should be read by the more advanced student.

‡ According to the rules of botanical nomenclature agreed upon by the Vienna Congress in 1905, the term "family" is now used in place of "natural order."

the subspecies or variety of another.* The main subdivisions of a phylum may be illustrated by the following example showing the systematic position of peppermint:—

<i>Phylum</i> ..	.. Angiospermæ.
<i>Subphylum</i> ..	.. Dicotyledons.
<i>Grade</i> ..	.. Sympetalæ.
<i>Order</i> ....	.. Tubifloræ.
<i>Suborder</i>	.. Verbenineæ.
<i>Family</i> ..	.. Labiataæ.
<i>Subfamily</i>	.. Stachydoideæ.
<i>Tribe</i> ..	.. Satureiææ.
<i>Genus</i> ..	.. <i>Mentha</i> .
<i>Species</i> ..	.. <i>Mentha piperita</i> , Linnæus † (Peppermint).
<i>Varieties</i>	.. <i>Mentha piperita</i> var. <i>officinalis</i> Sole † (White Peppermint). .. <i>Mentha piperita</i> var. <i>vulgaris</i> Sole † (Black Peppermint).

Biological Nomenclature.—Before the time of Linnæus many plants were known by a double Latin title, but it is to this great Swedish biologist that we owe the general adoption of the present binomial system. In this system the first name, which is always spelt with a capital letter, denotes the genus, whilst the second name denotes the species. Specific names are as a rule written with a small initial letter unless they are the name of a person or were formerly used as the name of a genus. Examples: *Capsicum minimum*, *Hydrastis canadensis*,

* Hutchinson, *The Families of Flowering Plants*, Vol. 1, p. 5: "A great divergence of opinion is evident in the two principal systems of classification in regard to the delimitation of families. Thus the number of families of flowering plants, including the Gymnosperms, in the *Genera Plantarum* is 200, in the *Pflanzenfamilien* 280, whilst the number is further increased in Engler and Güig's *Syllabus*. There is much to be said in favour of reducing the size of families whenever reasonably possible, and I am in favour of going slightly further even than Engler." . . . "On the other hand, I should consider it going too far to divide the *Compositæ* into the *Asteraceæ*, *Vernoniaceæ*, *Eupatoriaceæ*, etc., whilst the wisdom of separating the *Rosaceæ* into several families is rather doubtful. If more than one family be recognised in *Rosaceæ*, then at least ten will have to be segregated. I am not in favour of this undue multiplication. All this goes to prove that the delimitation of families, of genera, and of species is sometimes very much a matter of taste and personal idiosyncrasy. I should also add of judgment and experience!"

† These names refer to the botanists who described and named the species or variety. In the following pages they are frequently omitted except in cases where different names have been used for the same plant by different workers and there is possibility of confusion.

and *Cannabis sativa*. On the other hand *Cinchona Ledgeriana*, since the species is named after Charles Ledger, who in 1865 brought seeds of this plant from Brazil, while *Urginea Scilla* Steinheil has a capital S because the former name of the plant was *Scilla maritima* Linnæus.

The specific name is usually chosen to indicate some striking characteristic of the plant, e.g. the hemlock with the spotted stem is named *Conium maculatum* (*maculatus*, a, um, spotted). Sometimes the reason for the name is not so obvious as in the example just mentioned, but once it is discovered it will serve as a reminder of a characteristic of the plant, e.g. *Strychnos potatorum* (*potator*, oris, a drinker) bears a name which is only intelligible when it is known that the seeds of this species are used in India for clearing water. A glossary of words used in specific names will be found on p. 716.

Characters of Important Phyla.—Phylum **Thallophyta**.—The Thallophyta includes the Algæ, Fungi, and Lichens. The plant body is not differentiated into root, stem, and leaves. The Algæ contain chlorophyll and frequently other pigments, and are mainly aquatic. The Fungi are without chlorophyll and live as parasites or saprophytes. Lichens are dual organisms consisting of an alga and a fungus living in intimate relationship. Bacteria also belong to the Thallophyta, but they differ so much from other plants and are of such importance that they should be made the subject of separate study. For drugs derived from this phylum see Chapter XV.

Phylum **Pteridophyta**.—This phylum includes the Filicineæ (ferns), Equisetineæ (horsetails), and Lycopodineæ (club-mosses). These plants show an alternation of generations, the sporophyte generation being the larger. Very few members are of medicinal importance. For drugs derived from this phylum see Chapter XVI.

Phylum **Gymnospermæ**.—A phylum with many fossil members. Of the six orders, Cordaitales, Cycadales, Bennettitales, Ginkgoales, Coniferales (Coniferae), and Gnetales, only the last two are of medicinal interest. The pollen sacs and ovules are borne on sporophylls on different shoots. The ovules differ from those of the Angiosperms in that they are not enclosed in a chamber or ovary, but lie on the surface of the sporophylls. A perianth is absent except in the Gnetales. The seeds usually contain one mature embryo with two or more cotyledons embedded in endosperm. The wood is com-

posed largely of tracheids, vessels being absent. The leaves usually persist for more than one season. For drugs derived from members of this phylum see Chapter XVII.

Phylum Angiospermæ.—This phylum includes all the plants usually known as flowering plants, and is by far the most important phylum from the point of view of the pharmacist. The sporophylls (stamens and carpels) are usually arranged with other leaves (the perianth) to form a "flower." The ovules are enclosed in a chamber formed from the carpels, and a stigma is provided for the reception and germination of the pollen. The embryo has one or two cotyledons. The wood almost invariably contains true vessels. The phylum is divided into :

Subphylum 1. Monocotyledons.—Embryo with one cotyledon. Includes many herbs with parallel-veined leaves, and a stele of scattered, closed vascular bundles. Flowers usually trimerous. Drugs derived from members of this subphylum are dealt with in Chapter XVIII.

Subphylum 2. Dicotyledons.—Embryo with two cotyledons. Includes herbs, shrubs, and trees. Leaves reticulately-veined. Stems usually with a ring of open vascular bundles. Flowers usually pentamerous or tetramerous. The subphylum is divided into three grades * according to floral structure :

Grade A. Monochlamydeæ.—Perianth absent or, if present, generally undifferentiated. Flowers often unisexual, *e.g.* *Salicaceæ*. Drugs derived from members of this grade are dealt with in Chapter XIX.

Grade B. Dialypetalæ.—Perianth differentiated into sepals and petals. Petals free. Flowers generally hermaphrodite, *e.g.* *Ranunculaceæ*, *Cruciferae*, *Rosaceæ*, *Leguminosæ*, and *Umbelliferae*. Drugs derived from members of this grade are dealt with in Chapter XX.

Grade C. Sympetalæ.—Perianth differentiated into sepals and petals. Petals more or less fused. Flowers generally hermaphrodite, *e.g.* *Labiatae*, *Solanaceæ*, *Scrophulariaceæ*, and *Compositæ*. Drugs derived from members of this grade are dealt with in Chapter XXI.

* Alternatively dicotyledons may be grouped into two divisions :

1. *Archichlamydeæ*, which includes both Grade A and Grade B above.
2. *Metachlamydeæ*, the same as Grade C above.

CHAPTER XV

Phylum THALLOPHYTA

Order PHÆOPHYCEÆ (BROWN ALGÆ)

Family FUCACEÆ

FUCUS VESICULOSUS

Bladderwrack ; *F. Varech vésiculeux* ; *G. Blasentang*

Source and Collection.—Bladderwrack, *Fucus vesiculosus*, is a brown alga of common occurrence on the shores of the Atlantic. This and other species of *Fucus*, *Laminaria*, and *Ascophyllum*, when dried and burnt, yield kelp or varec, at one time the sole source of iodine. Bladderwrack found on the shore, although used for kelp manufacture, should not be used medicinally as it may have lost some of its constituents, and it is therefore advisable that the algæ be collected from the rocks at low tide and immediately dried.

Characters.—The drug consists of thin, more or less broken, thalli from 20 to 100 cm. long and about 2 cm. wide. The margin is entire (distinction from *Fucus serratus*). The air vesicles are oval, up to 2 cm. in length, and usually arranged in pairs (distinction from *Ascophyllum nodosum*, which has unpaired air-vesicles, and from *Fucus serratus*, which has none). Some of the branches have terminal enlargements owing to the presence of conceptacles containing either antheridia or oogonia. The discoid holdfast frequently remains attached to the rock. During drying the natural olive-green colour changes to almost black and the plant becomes hard and brittle. The dried drug has a faint odour of seaweed and an unpleasant, somewhat saline taste.

Constituents.—Bladderwrack contains two gum-like substances, algin (alginic acid) and fucoidin, also mannitol, sugars, iodine in organic combination, and halogen salts.

According to Kylin,* algin and fucoidin are found in the cell wall of *F. vesiculosus*, *Ascophyllum nodosum*, and *Laminaria digitata*. Algin is a white substance, insoluble in water but soluble in 1 per cent. sodium carbonate solution, forming a very viscous solution which has numerous commercial uses.† It has been used, for example, as a substitute for tragacanth in certain types of preparation. Both algin and fucoidin give a pentose reaction with phloroglucinol-HCl, and the pentose, arabinose, has been detected after hydrolysis.

The iodine content of bladderwrack is lower than those of other brown algæ, the analyses of Henrick‡ showing *Fucus vesiculosus* 0.04 per cent., *F. serratus* 0.05 per cent., *Ascophyllum nodosum* 0.09 per cent., *Laminaria digitata* fronds 0.38 per cent., and *Laminaria digitata* stems 0.54 per cent. of iodine. Dry bladderwrack also gave 16.08 per cent. of soluble ash, 3.30 per cent. of insoluble ash, and 3.44 per cent. of total halogen (calculated as chlorine).

Uses.—Bladderwrack preparations have been used to reduce obesity, but their value is doubtful. Compounds of iron and other elements with algin were described by Stanford § under the name of "Alginoids."

Order RHODOPHYCEÆ (RED ALGÆ)

Family GELIDIACEÆ

AGAR-AGAR

Agar, B.P.; *Japanese Isinglass*; F. and G. *Agar-agar*

Source.—Official agar is a dried, gelatinous substance prepared from *Gelidium corneum* (Huds.) Lamouroux, *G. cartilagineum* (Linn.) Gaill., and other allied red algæ. Japan, the main source of supply, produces about 1,500,000 kilograms annually, of which some 75 per cent. is exported. In other parts of the world agars resembling the Japanese product are prepared from different red algæ, e.g. Ceylon agar from *Gracilaria lichenoides* Greville, and Macassar agar from *Eucheuma spinosum* Agardh. Within recent years an agar closely resembling the Japanese product has been made in Southern California.

* Kylin, see abstract *Y. B. Pharm.*, 1913, 209.

† Gloess, see abstract *Y. B. Pharm.*, 1920, 138.

‡ Henrick, *J. Board Agric.*, 1916, 22, 1095.

§ Stanford, *Y. B. Pharm.*, 1898, 364.

Collection and Preparation.—On the Japanese coast the algæ are largely cultivated in special areas, poles being planted in the sea to form supports on which they develop. From time to time the poles are withdrawn and the algæ stripped off. Some is also collected from small boats by means of rakes or shovels, or even by diving. The algæ are taken ashore and dried; beaten and shaken to remove sand and shells; and bleached by watering and exposure to sunlight, the washing also serving to remove salt. They are then boiled with slightly acidulated water for several hours (about 1 part of dry algæ to 55 or 60 parts of water), and the mucilaginous decoction filtered, whilst hot, through linen. On cooling a jelly is produced which is cut into bars, these being afterwards forced through wire netting to form strips. The manufacture of agar only takes place in the winter (November to February), and moisture is removed by successively freezing, thawing, and drying at about 35°. The algæ are collected from May to October.

Characters.—Agar occurs in three forms:—(i) bundles of somewhat agglutinated, translucent, yellowish-white strips, these being about the thickness of leaf gelatin, 4 mm. wide, and about 60 cm. long; (ii) flattened yellowish bands about 4 cm. wide and 30 cm. long; (iii) coarse powder or flakes. "Strip" is the usual form, and drug market reports always contain a statement such as: "No. 1 Kobe strip . . . per lb., No. 2 . . . per lb."

Agar swells in cold water but does not dissolve. A 1 per cent. solution may be made by boiling, and a stiff jelly separates from this on cooling. A nearly boiling 0.2 per cent. solution gives no precipitate with an aqueous solution of tannic acid (distinction from gelatin). Agar also differs from gelatin in that it contains no nitrogen and it therefore gives no ammonia when heated with soda lime. Absence of starch may be proved by adding solution of iodine to a cooled decoction, or by mounting powdered agar in solution of chloral hydrate with iodine. If agar be ashed and the residue, after treatment with dilute hydrochloric acid, examined microscopically the silica skeletons of diatoms and sponge spicules will be found. More perfect diatoms can often be isolated by centrifuging a 5 per cent. solution for thirty minutes. The large discoid diatom *Arachnoidiscus Ehrenbergii* Baill., which is about 0.1 to 0.3 mm. in diameter, species of *Grammatophora*, *Cocconeis*, and sponge spicules are readily discernible in the ash of Japanese agar (see Fig. 62).

Constituents.—The chief constituent of agar is a calcium salt of an acid sulphuric ester of similar nature to that found in carrageen by Haas.* According to Fairbrother and Mastin † a simple agar solution contains calcium ions and no sulphate ions, but after hydrolysis with dilute hydrochloric acid both

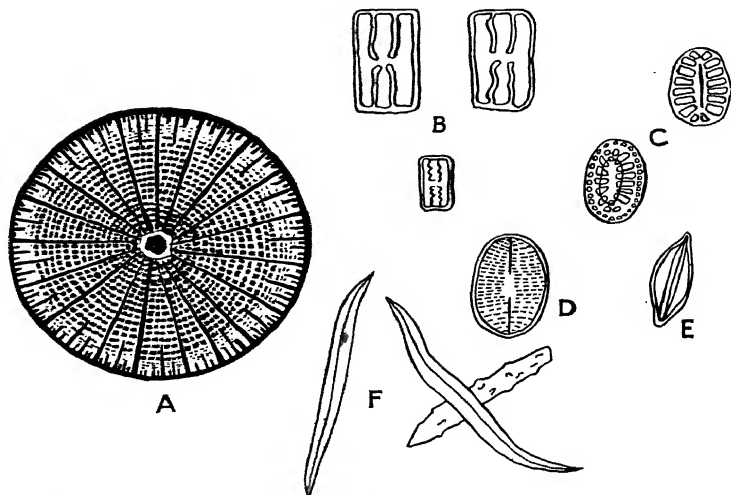
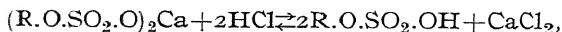


FIG. 62.—Diatoms and sponge spicules from agar. A, *Arachnoidiscus Ehrenbergii*; B, species of *Grammatophora*; C, *Campyloneis*; D, *Cocconeis*; E, *Navicula*; F, sponge spicules. (A after a photomicrograph by Ward, remainder after Thoms.)

calcium and sulphate ions are present. Hydrolysis may be represented by the equation :



the calcium salt and the free acid sulphuric ester being ionised to some extent. According to these workers the chief carbohydrate formed by hydrolysis is *d*-galactose. Other hexoses, and pentoses are found in smaller amounts. As hydrolysis proceeds the power of gelatinisation is lost. Commercial agar contains a small amount of water (Japanese Pharmacopœia not more than 1.5 per cent.), and yields about 3 to 4.5 per cent. of ash (B.P. not more than 5 per cent.).

* Haas, *Biochem. J.*, 1921, XV, 469.

† Fairbrother and Mastin, *Trans. Chem. Soc.*, 1923, 1412.

Uses.—Agar is used in the preparation of culture media, as an emulsifying agent, and in the treatment of chronic constipation.

Family GIGARTINACEÆ

CHONDRUS CRISPUS

Carrageen ; *Irish Moss* ; F. *Goëmon*, *Mousse d'Irlande*, *Mousse perlée* ; G. *Knorpellang*, *Irländisches Moos*, *Perlmoos*

Source.—Carrageen, *Chondrus crispus*, is a red alga common on the shores of the North Atlantic. Commercial supplies are derived from the north and north-west coast of Ireland, Sligo being an important centre ; from Brittany ; and from the Massachusetts coast south of Boston (Cape Cod Bay).

History.—The name *carrageen* or *carraigeen* means in Irish *moss of the rock*. The drug was introduced into medicine by Todhunter at Dublin in 1831. It is included in most pharmacopœias, but not in that of Britain.

Collection and Preparation.—The algæ grow on rocks just below low-water mark, being covered by about 15 or 20 feet of water at high tide. In Ireland collection takes place during the autumn, in America during the summer. The collectors put out in small boats at about half-tide and after detaching a load of algæ from the rocks by means of long rakes, return with them at half-flood. Carrageen is bleached by spreading it on the shore and submitting it for some weeks to the action of sun and dew with about four or five soakings in sea-water at suitable intervals. Chemicals such as sulphur dioxide are also said to be used.* After drying in sheds the drug is packed in bales each weighing about 50, 100, 200, or 300 kilograms.

Characters.—*Chondrus* when fresh varies in colour from purplish-red to purplish-brown, but the bleached drug is yellowish-white, translucent, and horny. It consists of complete, dichotomously branched thalli about 5 to 15 cm. long and of very variable form, some thalli having broad fan-like segments, others having ribbon-like ones. Many samples of *Chondrus* contain large quantities of the related alga *Gigartina mamilliosa*, the mixture being officially sanctioned in many pharmacopœias. In some districts, e.g. south of Boston, almost pure *Chondrus crispus* may be collected whilst in others, e.g.

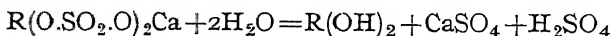
* See paper by Lawall and Harrison, *J. Amer. Pharm. Ass.*, 1932, 1150.

north of Boston, it is almost invariably closely associated with *Gigartina mamillosa*. These algæ may be distinguished from one another by the form of their large compound cystocarps, which contain carpospores. *Chondrus* has oval cystocarps about 2 mm. long which are sunk in the thallus, while *Gigartina mamillosa* has peg-like ones about 2 to 5 mm. long, as also has *Gigartina pistillata*. The latter species is rare round the coast of Britain, and its presence would indicate a drug of French origin.

Chondrus is sometimes covered with calcareous matter which effervesces with hydrochloric acid. The drug has a slight odour, and a mucilaginous and saline taste.

Chondrus swells in cold water, about 47 per cent. slowly dissolving, whilst on boiling about 75 per cent. passes into solution. A 5 per cent. decoction forms a jelly on cooling. A cooled 0.3 per cent. solution gives no precipitate with solution of tannic acid (distinction from gelatin), and gives no blue colour with iodine (distinction from Iceland moss and absence of starch).

Constituents.—*Chondrus* contains a gum-like substance, carrageenin, which, according to Sebor (1900) yields on hydrolysis galactose, glucose, fructose, and salts of sulphuric acid. Haas (1921) found that boiling water extracted from 70 per cent. to 75 per cent. of two colloidal, carbohydrate-yielding complexes which correspond to the formula $R(O.SO_2.O)_2Ca$. As there is no free sulphate ion the solution gives no precipitate with barium chloride, but after hydrolysis a precipitate is given with this reagent, and the hydrolysis therefore resembles that of agar.



The drug also contains about 7 per cent. of proteins and yields from 8 to 15 per cent. of ash containing traces of iodine.

Uses.—*Chondrus* is used as an emulsifying agent for cod-liver oil and other oils. It has demulcent and nutritive properties, and although it is not easily digested by invalids, it is used in Ireland as food for pigs and calves. It has various technical uses as a substitute for acacia gums.

Order ASCOMYCETES

Family HYPOCREACEÆ

ERGOTA

Ergota, B.P.; *Secale Cornutum* I.A.; *Ergot*; F. *Ergot de Seigle*; G. *Mutterkorn*

Source.—Official ergot is the sclerotium of a fungus, *Claviceps purpurea* Tulasne, arising in the ovary of the rye, *Secale cereale*. Ergot is produced in Spain (in the provinces of Galicia and Leon), in Portugal, in the U.S.S.R. (Tomsk, Omsk, and Viatka), Austria, Hungary, Czecho-Slovakia, Germany, and Scandinavia.

History.—There is considerable doubt as to whether ergot and ergotism were known to the ancients, and it is impossible to say if the "ignis sacer" of the Romans referred to ergotism. The outbreaks of "ignis St. Antonii," or St. Antony's fire, which occurred during the Middle Ages do, however, appear to have been of ergot origin. Undoubted outbreaks of ergotism occurred in Germany in 1581, 1587, and 1596, and at intervals in Europe until 1777. Ergotism was never common in England, probably owing to the fact that rye is little grown, and the only serious outbreak recorded, which took place in 1762, was caused by wheat.

The obstetric use of ergot was known in the sixteenth century, but the drug was not widely employed until the nineteenth century. It was first introduced into the London Pharmacopœia of 1836. It is now included in the pharmacopœias of all countries.

The fungoid origin of ergot was recognised by Münchhausen in 1764, while the life history of the fungus was worked out and the name *Claviceps purpurea* given to it by Tulasne in 1853.

Life History and Collection.—The fungus *Claviceps purpurea* and other species such as *C. microcephala* Wallr., *C. nigricans* Tul., and *C. Paspali* produce ergots on many members of the Gramineæ (including the genera *Triticum*, *Avena*, *Festuca*, *Poa*, *Lolium*, *Molinia*, and *Nardus*) and Cyperaceæ (including the genera *Scirpus* and *Ampelodesma*). Many of

these ergots appear to be extremely toxic and to produce typical ergotism.

In the case of the rye, the plant becomes infected in the spring or early summer by the ascospores of the fungus. These are carried by the wind or by insects to the base of the young ovary where in damp weather they find sufficient moisture to germinate, forming filamentous hyphæ which enter the wall of the ovary by enzyme action and form a soft, white mass over its surface. During this stage the sphacelia, as the white mass is called, produces a yellowish saccharine secretion, "honeydew," which will reduce Fehling's solution. At the same time chains of small oval conidiospores are abstricted from the ends of some of the hyphæ. The honeydew attracts ants, weevils, and other insects,* which carry the conidiospores to other plants and so spread the disease.

During the sphacelia stage the hyphæ only penetrate the outer part of the ovary, but as development proceeds they penetrate deeper and deeper, feeding on the ovarian tissue, and finally replacing it by a compact tissue (pseudoparenchyma), which forms the sclerotium or resting stage of the fungus. The sclerotium increases in size during the summer and projects, bearing the sphacelial remains at its apex, from the ear of the rye.

The number and size of the ergots produced on each spike of cereal by *Claviceps purpurea* varies, rye usually bearing a considerable number of sclerotia, while wheat bears very few. Ergot is either collected by hand or separated from the rye by special machines, that which is collected before the rye harvest being said to be the more active.

Any ergot which is not collected falls to the ground and in the following spring puts out a number of stalked projections known as stromata (Fig. 63, E). These have globular heads in the surface of which are a large number of flask-shaped pockets called perithecia. Each perithecium contains several sacs or asci, each of which contains eight of the thread-like ascospores which, as previously mentioned, infect the young rye ovaries in the spring.

Ergots will usually germinate in soil if they are exposed to frost. The ascospores obtained may be germinated on nutritive gelatin and large quantities of conidiospore-bearing

* Mercia (1911) observed *Claviceps conidia* being disseminated by the fungus-gnat, *Sciara thomæ*. It may be noted that a member of the same genus, *Sciara præcox*, causes serious damage to artificially reared mushrooms.

cultures obtained. A suspension of conidiospores may be used as a spray to infect rye plants.

Macroscopical Characters.—The drug consists almost entirely of sclerotia, the amount of other organic matter being officially limited to not more than 2 per cent. Each sclerotium

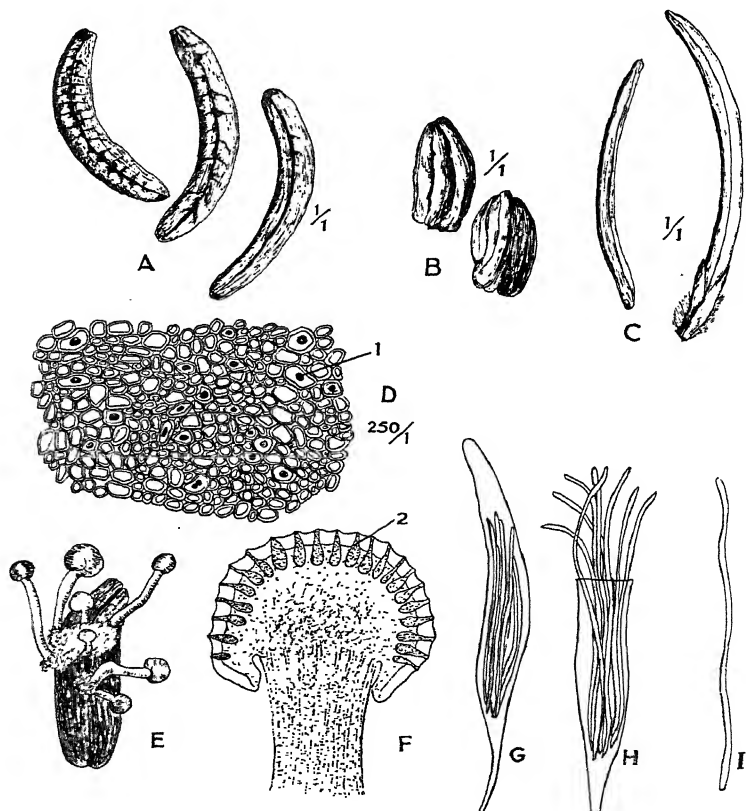


FIG. 63.—Ergot. A, ergot of rye; B, ergot of wheat; C, ergot of diss; D, transverse section of sclerotium; E, sclerotium with stromata; F, longitudinal section of fructification showing perithecia; G, ascus with eight filiform spores; H, a ruptured ascus with escaping ascospores; I, a single ascospore. 1, oil; 2, perithecium. (B and C after Hérail, D after Gilg, E to I after Tulasne.)

is about 1.5 to 4 cm. long and from 2 to 7 mm. broad ; fusiform in shape and usually slightly curved (*cf.* ergot of diss below). The outer surface, which is of a dark, violet-black colour, is often longitudinally furrowed and may bear small transverse cracks. Ergot breaks with a short fracture and shows within the thin, dark, outer layer a whitish or pinkish central zone of pseudoparenchyma in which darker lines radiating from the centre may be visible. Ergot has a characteristic odour and an unpleasant taste.

Powdered ergot when treated with sodium hydroxide solution develops a strong odour of trimethylamine. In filtered ultra-violet light it has a strong reddish colour by means of which its presence in flour may be detected.

Microscopical Characters.—Under the microscope ergot shows an outer zone of purplish-brown, rectangular cells, which are often more or less obliterated. The pseudoparenchyma consists of oval or rounded cells containing fixed oil and protein, and possessing highly-refractive walls which give a reaction for chitin (p. 119). Cellulose and lignin are absent. For powder, see p. 98.

Storage.—Ergot is particularly liable to injury by insects, moulds and bacteria. After collection it should be thoroughly dried, kept entire, and stored in a cool, dry place. If powdered and not immediately defatted the activity decreases, but if defatted and carefully stored in an air-tight container it will remain active for a long period. Any sample of ergot which shows worm holes or a considerable amount of insect debris will almost certainly deteriorate further on keeping.

Constituents.—During the last few years great advances have been made in our knowledge of the constituents of ergot. The chief constituents are alkaloids. The chief active alkaloids are ergotoxine (isolated in 1906 independently by Barger and Carr and by Kraft), ergotamine (isolated in 1920 by Spiro and Stoll) and ergometrine (isolated in 1935 by Dudley and Moir). Ergotamine may or may not be present in the official ergot of rye, but has been isolated from ergots grown on fescue grass.

These three active alkaloids are easily converted into closely related but physiologically inert alkaloids, which are also present in the drug. It has now been shown that all six alkaloids are derivatives of lysergic acid which they yield when suitably oxidised. Ergine, $C_{17}H_{21}ON_3$, the amide of lysergic acid, is obtained from all but ergometrine and ergometrinine

on treatment with alcoholic potash. These relationships may be summarised as follows :—

<i>Active Alkaloids</i>	<i>Inactive Alkaloids</i>	<i>Components</i>
Ergotoxine $C_{33}H_{50}O_2N$	Ergotinine	Lysergic acid } Ammonia } ergine Proline Phenylalanine isobutylformic acid
Ergotamine $C_{33}H_{35}O_5N_5$	Ergotaminine	Lysergic acid } Ammonia } ergine Proline ? Phenylalanine Pyruvic acid
Ergometrine $C_{19}H_{23}O_2N_3$	Ergometrinine	Lysergic acid β -aminopropyl alcohol (hydroxyisopropylamine)

Among the lesser important constituents of ergot may be mentioned histamine, tyramine and other amines and amino acids, acetylcholine; colouring matters; sterols (ergosterol and fungisterol), and about 30 per cent. of fat. The cell walls are chitinous.

Varieties.—Spanish and Portuguese ergots are usually of good appearance and high activity, and are generally preferred. The so-called Russian and Polish ergots are usually more variable, many samples being of small size, while the alkaloidal value is often low. Ergot is assayed colorimetrically, the alkaloids giving a blue colour with a solution of dimethylaminobenzaldehyde. This colour is compared with that produced with a standard solution of ergotoxine ethane-sulphonate.

Substitutes.—*Ergot of Wheat* is rare in Britain, but has been used medicinally in France. The sclerotia are shorter and thicker than those of rye.

Ergot of Oats has been used medicinally in Algiers. The sclerotia are black in colour, 10 to 12 mm. in length and 3 to 4 mm. in diameter.

Ergot of Diss, which is produced on the Algerian reed *Ampelodesma tenax*, has appeared in commerce and is said to be highly active. The sclerotia may attain as much as 9 cm. in length and are spirally twisted (Fig. 63 C).

Uses.—Ergot is used in labour to assist delivery and to reduce post-partum hæmorrhage. Only ergometrine produces an oxytocic (literally "quick-delivery") effect, ergotoxine

and ergotamine having quite a different action. See Barber's *Textbook of Physiology*, pp. 445 and 446. Ergometrine is soluble in water or in dilute alcohol.

Family **PARMELIACEÆ**

CETRARIA

Iceland Moss; F. *Lichen ou Mousse d'Islande*; G. *Isländisches Moos*

Source.—Iceland moss, *Cetraria islandica*, is a foliaceous lichen growing amidst moss and grass in North Europe, Siberia, North America, and on the lower mountain slopes of Central Europe and Spain. For medicinal purposes it is usually collected in Scandinavia and Central Europe.

History.—This lichen has long been used as an emergency food by the Lapps and Islanders, being first freed from its bitterness by maceration in water. In Scandinavia it has been used for pulmonary diseases since the seventeenth century.

Characters.—*Cetraria islandica* is a rapid-growing lichen which increases by several cm. yearly until it attains a length of about 10 cm. The drug consists of irregularly lobed, leafy thalli, about 5 to 10 cm. in length and about 0.5 mm. in thickness. The upper surface is greenish-brown and sometimes covered with reddish points, while the lower surface is pale brown or greyish-green and marked with white, irregular spots. At frequent intervals along the margin of the thallus are minute projections, which are known either as spermogonia or pycnidia (and their contents as spermatia or pycnidiospores) according to the view taken of their function. The apothecia which contain asci and ascospores are circular, dark reddish-brown, and about 0.5 cm. in diameter. They are, however, rarely found in the drug.

The dried drug is brittle but becomes cartilaginous on moistening with water. Odour, slight; taste, mucilaginous and bitter. A 5 per cent. decoction forms a jelly on cooling, which is stained blue by iodine (distinction from carrageen).

Sections of the drug reveal the dual nature of the plant. The small rounded cells of the unicellular alga *Cystococcus humicola* being enclosed by the more or less closely-woven hyphæ of the fungus. Sections through a spermogonium and an apothecium are shown in Fig. 64.

Constituents.—The hyphal cell walls of most lichens are composed of chitin. *Cetraria islandica* is, however, one of the few exceptions, the walls in this lichen consisting of carbo-

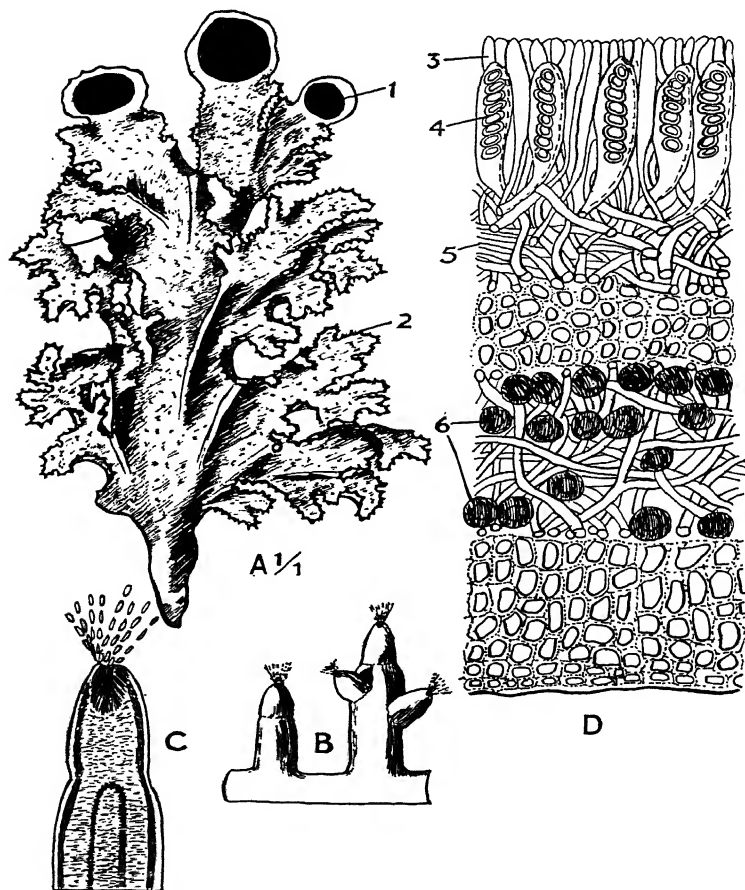


FIG. 64.—*Cetraria islandica*. A, plant bearing three apothecia and numerous spermogonia; B, margin of thallus showing spermogonia; C, spermogonium shedding spermatia; D, section through a ripe apothecium. 1, apothecium; 2, spermogonium; 3, paraphyses; 4, asci each containing eight ascospores; 5, subhymenial layer; 6, algal cells. (All after Gilg.)

hydrate which was called by Berzelius (1813) "lichen-starch" or "moss-starch." The name "lichenin" was applied to the carbohydrate matter extracted by water, and examination of this by Mulder (1838), Berg (1873), and Beilstein (1881) led to the isolation of two isomers of the formula, $C_6H_{10}O_5$, which are known as lichenin and isolichenin. Lichenin is only soluble in hot water and is not coloured blue by iodine; while isolichenin is soluble in cold water and gives a blue colour with iodine. Both on hydrolysis give galactose.

The bitter taste of *Cetraria islandica* is mainly due to a lichen-acid* of the oricine group formerly known as "cetrarin" or "cetraric acid," but shown by Hesse (1904) to be fumarprotocetraric acid, $C_{62}H_{50}O_{35}$, which is also found in other lichens. Hesse (1916) shows that the potassium salt of this acid may be isolated from the drug by extraction with acetone, and that it is readily decomposed into potassium fumarate and cetraric acid, the latter not occurring in the drug in the free state.

The drug also contains a fat acid, proto- α -lichesteric acid, which on heating above 45° is more or less converted into α -lichesteric acid, $C_{18}H_{30}O_5$.

Uses.—Iceland moss has been used as a bitter tonic and as a demulcent, but it is now little employed in Britain, although official in many foreign pharmacopœias.

* More than one hundred lichen-acids are known. These have been provisionally arranged by Zopf into: 1, Lichen-acids of the Fat Series; and 2, Lichen-acids of the Aromatic Series. The latter class is subdivided into: (a) Orcine derivatives; and (b) Anthracene derivatives. These acids occur on the outer surface of the hyphæ, are crystalline and frequently have a bitter taste. Many are colourless, but others are bright yellow, orange, or red.

The colouring matters of certain lichens are of commercial importance, products such as orchil, cudbear (persio), and litmus being prepared from them. Species of *Rocella* contain erythrin, $C_{20}H_{22}O_{10}$, or lecanoric acid, $C_{11}H_{14}O_7$. By means of ammonia these are split up, yielding oricine or orcinol, 3:5 dihydroxymethylbenzene, $C_6H_3(CH_2)(OH)_2$. Orcein, $C_{14}H_{12}N_2O_3$, the colouring matter of orchil and cudbear, is prepared from oricine by prolonged exposure to the influence of ammonia and atmospheric oxygen. Commercial litmus is prepared in a somewhat similar manner and contains azolitmin (which may be prepared from orcinol), erythrolein, and erythrolitmin.

CHAPTER XVI

Phylum PTERIDOPHYTA

Order FILICALES

Family POLYPODIACEÆ

FILICIS RHIZOMA

Filix Mas, B.P. ; *Aspidium* ; Male Fern Rhizome ; F. Racine de Fougère Mâle ; G. Wurmfarne, Farnwurzel, Wurmfarneurzel

Source and Collection.—Official male fern consists of the rhizome and leaf bases of *Dryopteris Filix-mas*. The fern is dug up in the late autumn, divested of its roots and dead portions, and carefully dried. It must be used within one year of collection. Although common in England, male fern is largely imported from Germany, both in the form of the dried drug and as oleo-resin obtained by ether extraction. It is collected in large quantities in the Harz and Thuringian mountains. The U.S.A. import little or no rhizome from Europe, but considerable quantities of the oleo-resin.

Plant.—The gametophyte, or gamete-bearing, generation consists of a small, heart-shaped prothallus about 5 mm. in length, which bears antheridia and archegonia. The sporophyte consists of a number of large, leafy fronds arising from a stout rhizome which bears numerous fine rootlets on its lower surface. The fronds are rolled lengthways when young (circinate vernation) and the bases and petioles are densely covered with shaggy scales (ramenta).

History.—The vermifuge properties of ferns were known to the ancients, their use being mentioned in the works of Dioscorides, Theophrastus, Galen and Pliny. After a long period of disuse male fern was popularised in 1775 by Louis XVI of France. He paid a large sum (about £700) for the secret of a very successful tapeworm remedy, which proved to be powdered male fern, and caused an account of the drug to be published. After again lapsing into disuse it was reintroduced by a French physician, Jobert, in 1869. It is now official in most pharmacopœias.

Macroscopical Characters.—The drug occurs in pieces about 7 to 15 cm. in length, consisting of a rhizome about 2 cm. in diameter surrounded by frond bases which bring the total diameter of the pieces to about 4 or 5 cm. Some of the larger

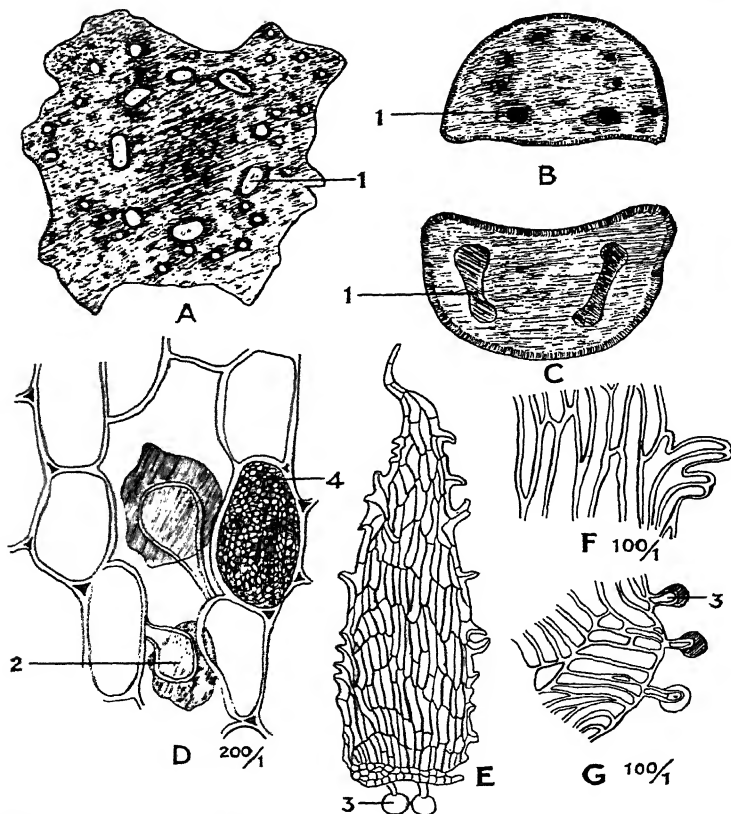


FIG. 65.—A, transverse section of rhizome of *Aspidium Filix-mas*; B, transverse section of leaf base of same; C, transverse section of leaf-base of *Athyrium Filix-femina*; D, section through male fern rhizome showing intercellular glands; E, ramentum of male fern; F, edge of same; G, edge of ramentum of *Aspidium spinulosum*. 1, meristele; 2, intercellular gland; 3, glandular hair; 4, starch. (A after Berg, B and C after Luerksen, D after Brandt and Wasicky, E, F, and G after Tschirch and Lauren.)

pieces have been sliced to facilitate drying. The frond bases are brown externally and densely covered withramenta; internally they are green, and show in transverse section from 7 to 9 pale yellow meristemes (distinction from *Athyrium Filix-fœmina*). The rhizome is brownish externally and yellowish-green internally, if official. On long storage the interior becomes brown, the activity decreases, and the drug is no longer fit for use. A section of the rhizome shows from 7 to 9 large meristemes arranged in a diffuse circle and external to these the smaller meristemes running from the fronds. The drug has little odour. The taste is at first sweetish, afterwards becoming bitter and extremely nauseous.

Microscopical Characters.—Sections of the rhizome show: (i) within the epidermis a hypodermis of brownish sclerenchymatous fibres; (ii) a ground work of parenchyma which is rich in starch grains up to 18μ in diameter, and which possesses shortly stalked, internal secreting glands in its intercellular spaces; (iii) meristemes, which are largely composed of large tracheids with pointed ends and scalariform thickening. Crystals of calcium oxalate are absent. The ramenta have very characteristic two-celled marginal projections and usually two small glands at the base (see Fig. 65, E).

Constituents.—The chief active constituent of male fern is a complex dibasic acid, filmarone, $C_{47}H_{54}O_{16}$, which was isolated by Kraft in 1904.

Before this date filicic acid, $C_{35}H_{39}O_{12}$, aspidinol, $C_{17}H_{16}O_2$, flavaspidic acid, albaspidin, filicinylbutanone, and filicinic acid had been isolated. The structures of these compounds were largely elucidated by Boehm (1902-3), who showed them to be derivatives of butyric acid and phloroglucinol. Aspidinol, for example, on treatment with zinc dust and sodium hydroxide, yields methylphloroglucinol monomethyl ether and butyric acid.

Filmarone occurs in the drug to the extent of about 5 per cent. It is a yellowish-brown, amorphous substance, having the properties of a dibasic acid. It is insoluble in water, sparingly soluble in alcohol, but soluble in most other organic solvents. Dissolved in acetone it slowly decomposes into filicic acid and filicinigrins, a similar change taking place in the official extract and giving rise to a granular deposit on keeping. Boiling with 15 per cent. sodium hydroxide solution and zinc dust decomposes filmarone into filicic acid, phloroglucinol or its derivatives, and butyric acid. According to

Gommerman (1907) it is stable when boiled with ammoniacal silver oxide or with Fehling's solution, and the enzymes pepsin, trypsin, and pancreatin exert no action on it.

Clinical tests show that neither filicic acid not flavaspidic acid have any appreciable anthelmintic action; albaspidin shows a slight action; while filmarone in doses of 0.5 to 0.7 G. was successful in thirty cases.

The drug also contains filicitannic acid, resin, and starch. It yields from 1.5 to 4.3 per cent. of ash (B.P. not more than 6 per cent. of ash, and not more than 2 per cent. of acid-insoluble ash).

Assay.—The official assay process estimates the weight of a mixture of ether-soluble, acidic substances to which the name "filicin" is given. Pabst and Bliss * give a modification of this process which they claim to be more accurate. A biological assay on earthworms is said to be satisfactory but lengthy.

According to Peyer † male-fern extracts frequently contain traces of copper and of ether. He suggests a flash-point test for the detection of small quantities of the latter.

Substitutes.—*Athyrium Filix-femina*, the lady fern, sometimes occurs in samples of male fern. It may be distinguished by the leaf bases, which show two dumb-bell shaped steles, and by the entire margins of the ramenta.

Dryopteris spinulosa O. Kuntze (*Aspidium spinulosum* Sw.), the shield fern, has often been found in German samples of male fern. The rhizomes usually have rather fewer steles than male fern, but the most reliable character is the presence of numerous small glands on the margins of the ramenta. This fern has similar internal glands to those of male fern and is a very active tannicide.

Dryopteris pseudo-filix-mas is a Japanese fern which was formerly believed to be identical with *D. Filix-mas*. Investigations of Ishio and Shimidzu (1919) show that the ramenta lack the characteristic marginal projections and the two basal glands which are found in the official drug. The oleo-resin gave no less than 49.51 per cent. of filicin when assayed by the official method.

Dryopteris marginalis, an American fern, was formerly official in the U.S.P.

Uses.—Male fern, usually in the form of the official extract,

* Pabst and A. R. Bliss, junr., *J. Amer. Pharm. Ass.*, 1932, 21, 431.

† Peyer, *Apoth. Ztg.*, 1928, 45, 348.

POLYPODIACEÆ—LYCOPODIACEÆ

is used as a tænicide. Its use requires
occurred in which it has been absorbed in q
in blindness. A 10 per cent. solution of filmarone
is also used.

Order LYCOPODIALES

Family LYCOPODIACEÆ

LYCOPODIUM

Lycopodium Spores; *Clubmoss Spores*; *F. Lycopode*;
G. Barlappsamen, Hexenmehl

Source.—*Lycopodium* consists of the spores of the clubmoss, *Lycopodium clavatum*, and possibly other species of *Lycopodium*. The plant is very widely distributed in the temperate and colder parts of the world, being found not only in Europe, Asia, and North America, but also in Australia, South Africa, and South America. The commercial drug is collected in Poland and the Ukraine, and reaches London via Danzig or Hamburg.

History.—The drug was known to the early botanists of the sixteenth century, and it was used in Germany as an application to wounds in the seventeenth century. It is official in the U.S.A. and in many Continental countries.

Collection.—In July and August the sporangial spikes are cut and dried. The spores are separated by shaking, and are then freed from vegetable debris by sieving through flour-sieves. The drug is exported in sacks which are usually enclosed in matting. It is generally quoted in London as "triple sifted" lycopodium.

Macroscopic Characters.—*Lycopodium* is a light, yellow, extremely mobile powder without odour or taste. It floats on water without being wetted. When thoroughly crushed in a mortar it assumes a greyish tint, gives an oily stain to paper, and may be mixed with water. When blown into a flame it ignites with a brilliant flash.

Microscopic Characters.—Under a microscope the spores are seen to be from 21 to 30 μ in diameter, and to have the shape of a three-sided pyramid with a convex base. The surface is covered with polygonal-shaped reticulations, which form a projecting ridge at the edge of the spore. Viewed from the apex of the pyramid, the edges of the flat sides form a

distinct, triradiate marking. On crushing, yellowish drops of oil exude. The spores of other *Lycopodium* species closely resemble the above, but may be distinguished microscopically.

Constituents.—*Lycopodium* contains about 50 per cent. of fixed oil, which consists mainly of the glycerides of lycopodium-oleic acid and myristic acid. The drug also contains about 3 per cent. of sugars, phytosterin, and traces of an alkaloid.

Adulteration.—Adulteration with the pollen of *Pinus* species, *Corylus avellana*, *Typha latifolia*, etc., or with roasted and coloured starches, dextrin, sulphur, or inorganic salts, can be readily detected by means of the microscope. Pure samples of the spores yield little more than 1 per cent. of ash, and more than 4 per cent. of ash would indicate adulteration.

Uses.—*Lycopodium* is used to a limited extent in dusting powders and medicated snuffs, and as a dusting powder for pills. It is extremely useful in quantitative microscopy (see p. 155).

CHAPTER XVII

Phylum GYMNOSPERMÆ

Order CONIFERALES (CONIFERÆ)

THE order Coniferales consists of the six families, Taxaceæ, Podocarpaceæ, Araucariaceæ, Pinaceæ, Taxodiaceæ, and Cupressaceæ. The members are trees or shrubs, mostly evergreen, with needle-like leaves; monœcious or diœcious. Sporophylls usually in cones. Fruit generally woody (*e.g.* *Pinus*), but sometimes succulent (*e.g.* *Taxus*). Seeds woody and often winged.

Family TAXACEÆ

A family of four genera, only one of which, *Taxus*, is represented in Britain. The members are characterised by the presence of 3 to 8 pollen sacs in the stamens; erect ovules; fleshy fruits; and embryo with two cotyledons.

***Taxus Baccata*.**—The common yew, *Taxus baccata*, is an evergreen shrub or tree up to 10 m. in height. The trunk is thick and covered with a greyish-brown, channelled bark. The leaves are linear and about 1.5 to 2.5 cm. in length. The male cones are very small and consist of 6 to 15 stamens, each of which has a peltate head and 3 to 8 pollen sacs. The erect ovules are borne singly. The seed is about 1 cm. in length and is surrounded by a cup-like aril. The latter changes from green to a bright red, and becomes succulent on ripening.

Yew owes its poisonous properties to an alkaloid, taxine, which is widely distributed in the plant and occurs in the leaves to the extent of 0.7 to 1.4 per cent. It also contains a glycoside (taxatin), raffinose, calcium malate, and a little volatile oil.

Family PINACEÆ

A family consisting of 9 genera, and about 130 species. The chief genera are *Pinus*, *Larix* (larch), *Cedrus* (cedar), *Picea* (spruce fir), *Tsuga* (hemlock fir), and *Abies* (silver fir). These plants are characterised by the two pollen-sacs on the lower side of the male cone scales, and by the two anatropous ovules on the upper side of the female cone scales. The cone scales are spirally arranged (*cf.* Cupressaceæ).

Pinus Sylvestris.—The Scots pine, *Pinus sylvestris*, is an evergreen tree about 30 to 40 m. in height. The trunk is covered with a dark-brown, scaly bark, which tends to exfoliate, leaving a copper-coloured surface exposed. The tree bears shoots which end in a bud and have indefinite growth ("long" or "leader" shoots), and very short shoots of limited growth ("dwarf shoots" or "bifoliar spurs"). The latter bear acicular leaves about 3 to 6 cm. long. The pine is monœcious. The staminate cones are arranged spirally in groups of 20 to 60. Each consists of a number of spirally arranged sporophylls bearing a pair of pollen sacs on their lower surfaces. The pollen grains, which are shed in June, have been found in samples of lycopodium, but are easily recognised microscopically by their bladder-like wings. The pistillate cones occur singly or in groups of two or three in the position of leader shoots. They take three years to arrive at maturity. In the third year the cones are 4 to 6 cm. in length, woody, and dark brown in colour. The seeds are from 3 to 5 mm. long and are provided with a wing about 15 to 20 mm. in length.

Schizogenous oleo-resin ducts occur in the leaves, stem, and root of all pines (see below). Pine and other coniferous woods are sometimes used to adulterate powdered drugs. They may be detected microscopically by the characteristic tracheids with bordered pits described under wood pulps (p. 137).

OLEO-RESINA PINI

Crude Turpentine

Source.—A large number of the eighty to ninety known species of *Pinus* are used for the production of resin and turpentine. The following species are particularly important: (i) In the South and South-Eastern U.S.A., *Pinus palustris* Miller (*P. australis* Michaux), the long-leaf pine; *P. echinata* Miller, the short-leaf pine; *P. caribæa* Morelet (*P. heterophylla* Sudworth); (ii) in France, *Pinus maritima* Lamarck (*P. pinaster* Solander); (iii) in India, *Pinus longifolia* Roxburgh.

History.—Pine and fir resins were well known to the Ancients, and essential oil of turpentine is said to have been known to Marcus Græcus, the reputed inventor of the Greek fire used in mediæval warfare. Up to the eighteenth century our supplies of resin and turpentine were obtained mainly from France, but America is now by far the most important source of supply.

Collection of the Crude Oleo-Resin.—Although oleo-resin is a normal (physiological) product of pines the amount produced by the trees is greatly increased by injury. The chief methods for the collection of crude turpentine, *i.e.* the oleo-resin, are as follows:—

Box Method.—This method is now becoming of little more than historic interest since the trees are “tapped to death” in about four years. In the spring a large incision is made in the bark and sapwood of the trunk gradually becoming deeper as it gets about 18 inches from the ground where it ends in a pocket-like cavity known as a “box.” Later in the year a broad band of bark is removed for some distance above the box and this area is shaved every few weeks to maintain a flow of oleo-resin into the box. At intervals the oleo-resin is removed from the box by means of a dipper, and sent in barrels to the distillery.

This wasteful method formerly led to the destruction of vast areas of American forests. In many cases the timber was removed and the stumps left in the ground. Many of the latter have since been removed and the wood distilled to yield “wood turpentine” or “stump turpentine” (see below).

Cup and Gutter Method.—This method, with different modifications, is used in America*, France†, and other European countries, and India. Fig. 66 gives some idea of the method, but a wider groove, which may be spiral or vertical, is more common. At first the groove is only a few feet long, but the worker visits the tree at intervals and with a special long-handled, axe-like instrument removes shavings from the groove and, in about four years, increases its length to about 12 feet. The metal or earthenware cups are attached to the trunk by nails and one or two strips of galvanised iron are placed above each to direct the flow of oleo-resin. As the grooves are lengthened the cups are moved higher up the tree and new grooves are started when the old ones become exhausted or collection too difficult. The cups are emptied at intervals and the oleo-resin sent to the distillery. Trees can be tapped by this method for about forty years, commencing when the tree is about twenty to thirty years old.

* Production in America is described and illustrated in “A Naval Stores Handbook,” 1935, U.S. Dept. of Agriculture, *Miscellaneous Publication No. 209*.

† The French Method is described and illustrated in an article by K. M. Hutchin, “Collection of Crude Turpentine and Resin in the Landes Department of France,” *P.J.*, 1927, **119**, 245.

The product known as "gum thus," "American," or "common frankincense," consists of the last portions of the exudation, which become semi-solid before reaching the "box" or "cup."

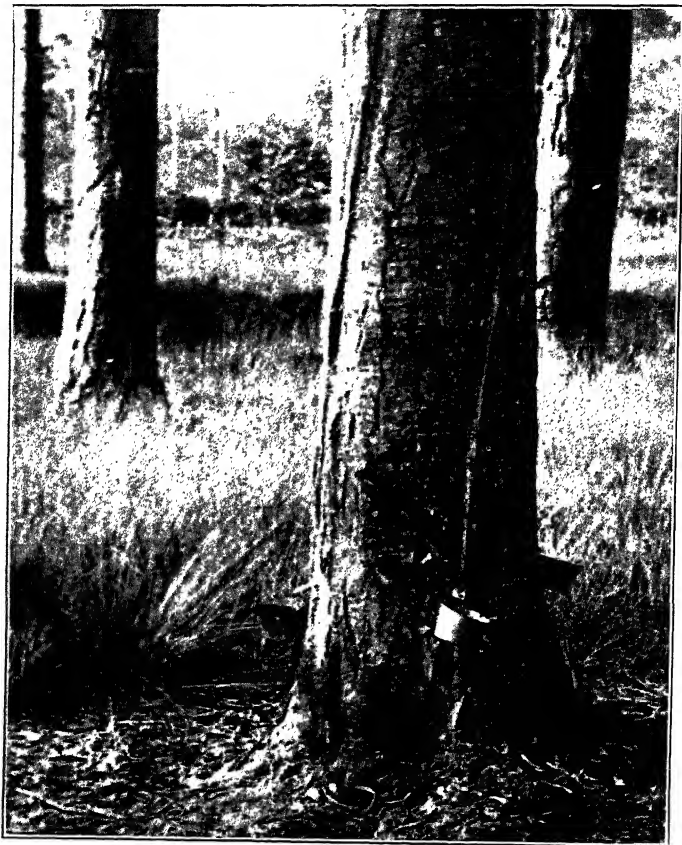


FIG. 66.—Collection of crude turpentine.* (Ayers.)

* The above photograph was sent to me by a past student, Mr. W. O. Ayers. It represents an experimental tapping made in England during the war. Some of the abandoned cups have been acquired by Mr. T. C. Denston and may be seen in the Chelsea Polytechnic.

COLOPHONIUM

Colophonium, B.P.; *Colophony Resin*, *Resin*, *Rosin*, *Amber Resin*; F. *Colophane*; G. *Geigenharz*

Preparation.—The crude oleo-resin (see above) arrives at the distillery in barrels. It is transferred to copper stills in which it is warmed with water, any woody debris floating to the surface being skimmed off. The head of the still is then fixed, the temperature is raised, and distillation commences. The distillate is a mixture of water and oil of turpentine. To prevent charring of the resin water is added as required. When no more turpentine passes over the molten resin is run through wire strainers into barrels, in which it cools and is exported.

Speaking generally the resin obtained from trees during their first year of tapping is of a lighter colour than that obtained subsequently. The following fourteen grades of American resin are recognised: B, C, D, E, F, G, H, I, K, L, M, N, W-G (window-glass), and W-W (water-white). Grade B is almost black, the colour gradually changing through the other grades up to the very pale "water-white."

Characters.—The colophony used in pharmacy occurs in translucent glassy masses of a pale yellow or amber colour. It is brittle and easily powdered. It fuses gradually at about 100°, and at a higher temperature burns with a smoky flame, leaving not more than about 0.1 per cent. of ash. Colophony is insoluble in water but soluble in alcohol, ether, benzene, and carbon disulphide.

Chemical Tests.—Students should apply the following tests:—*

(1) Dissolve about 0.1 G. of powdered resin in 10 ml. of acetic anhydride. Add one drop of sulphuric acid on a glass rod. Care should be taken to see that the apparatus used is dry, that the solution is cold, and that concentrated sulphuric acid is used. On adding the acid a purple colour, rapidly changing to violet, is produced.

* The above colour tests are not specific for colophony resin, but are given by a number of related substances, notably Burgundy pitch, gum thus, Canada turpentine, and Venice turpentine.

The following test, suggested by Foester (*Ann. Chim. Anal. Appl.*, 1909, 14, 14), is useful for the detection of resin or rosin oil when admixed with other substances. A little of the material to be tested is dissolved in a dish in 2 ml. of a solution consisting of phenol (1 part), and carbon tetrachloride (2 parts). A second dish containing bromine (1 part) and carbon tetrachloride (4 parts) is placed near the first dish. The bromine vapour given off produces a blue colour, changing to violet at the surface of the colophony-containing solution. See also Dieterich, *Analysis of Resins*.

(2) Shake a little powdered colophony with light petroleum and filter. Old samples of resin are usually much less soluble in this solvent than fresh ones. Shake the solution with about twice its volume of dilute solution of copper acetate. The petroleum layer becomes emerald-green in colour, a change which is said to be due to the formation of the copper salt of abietic acid.

(3) The alcoholic solution is acid to litmus. If time permits, the acid value of colophony should be determined by the official method.

Constituents.—Colophony contains several isomeric forms of the anhydride of abietic acid, which are present to the extent of more than 80 per cent. These anhydrides were named by Tschirch and Studer (1904) α -, β -, and γ -abietinic acid, but the name abietic acid is often applied to them. The parent acid, abietic acid, has the formula $C_{20}H_{30}O_2$, and is thus isomeric with pimaric acid.* The commercial so-called "abietic acid" is prepared by digesting colophony with weak alcohol. Colophony also contains a resene, the bitter-tasting colophenic acids, and traces of volatile oil.

Abietic acid, $C_{20}H_{30}O_2$, was isolated by Fahrien (1902). It has an acid value of 185.4 (compare colophony 150 to 180). Abietic acid is liable to spontaneous oxidation and prolonged heating converts it into its anhydride, the presence of which in the drug can be thus explained. The constitution of abietic acid has been investigated by Levy (1913), Perth (1916), Madinaveitia (1922), Aschan, Fontell, and Simola (1922), and by Ruzicka and his co-workers (1922-25).†

Uses.—The amount of colophony used in pharmacy for the preparation of plasters, ointments, etc., is relatively small. Large quantities of the darker grades B, C, and D, are destructively distilled to yield "rosin spirit" and "rosin oil" or are employed in the manufacture of linoleum and dark varnishes. Grades E, F, and G are used as size. The medium grades are largely used for the manufacture of soap and the lighter grades for sealing-wax, light varnishes, and in pharmacy.

* Pimaric acid is said to differ from abietic acid in having a bitter taste and in forming an ammonium salt which crystallises in fine needles, while the corresponding abietic salt is gelatinous. It has been suggested by Duffour (1922) that the anhydrides found in colophony are formed from pimaric and not abietic acid.

† See Ruzicka and Pfeiffer, *Helv. Chim. Acta.*, 1925, 8, 632; abstracted in *J.C.S.*, 1925, 1, 1419.

OLEUM TEREBINTHINÆ

Oleum Terebinthinæ, B.P. ; *Oil of Turpentine*, *Rectified Oil of Turpentine* ; F. *Essence de Térébenthine* ; G. *Terpentinöl*

Source and Preparation.—The oil of turpentine used in medicine is the volatile oil distilled from the oleo-resin of pines which is afterwards rectified. The purification consists of treatment with aqueous alkali to remove traces of phenols, cresols, resin acids, etc., followed by rectification.

Characters.—Oil of turpentine is a colourless liquid with a characteristic odour and a pungent taste. It is soluble in alcohol, ether, chloroform, and glacial acetic acid. Oil of turpentine is optically active, but the rotation varies not only with the species of pine from which it has been obtained but also in samples taken from the same tree at different periods. Samples taken from the same tree at different times have given rotations varying from $-7^{\circ} 26'$ to $+18^{\circ} 18'$ in the case of *Pinus palustris*, and $-29^{\circ} 26'$ to $+1^{\circ} 23'$ in the case of *Pinus heterophylla*. The French oils from *Pinus maritima* are strongly lævorotatory (-20° to -38°). The optical rotation of American turpentine has progressively decreased over a period of years, a change which may be attributed to the use of different species of *Pinus* and to changes in the method of collection and preparation.

Constituents.—Oil of turpentine consists chiefly of the terpenes *d*- and *l*- α -pinene, β -pinene, and camphene. These tend to undergo atmospheric oxidation with the formation of complex resinous substances, the removal of which is accomplished by the process of rectification mentioned above. The varying optical rotations of different turpentines are mainly due to the varying proportions of the *d*- and *l*- α -pinenes which they contain.

Adulterants.—The determination of the iodine value is useful for the detection of wood turpentine, which has an iodine value of 240 to 264 (B.P. oil not less than 340). After steam distillation there should be little or no residue (absence of petroleum naphtha, etc.). Rosin spirit is almost optically inactive. The specific gravity, refractive index, and temperature of distillation also afford evidence as to purity.

Uses.—Oil of turpentine is used externally as a counter-irritant and rubefacient. Small doses of oil of turpentine are given internally for bronchitis and phthisis, and larger doses

as an anthelmintic. An oil of turpentine inhalation is sometimes used for bronchitis, but terebene is usually preferred for this purpose. Terebene is prepared from oil of turpentine by the action of cold sulphuric acid, which converts the pinene into the optically inactive *dl*-limonene, which is known as dipentene.

PIX LIQUIDA

Pix Liquida, B.P., *Pix Pini*, *Tar*, *Wood Tar*, *Stockholm Tar*; *F. Goudron Végétal*, *Goudron de Pin*, *Goudron de Norvège*, *Goudron d'Arkhangel*; *G. Holztheer*

Source.—Official tar is that known in commerce as Stockholm tar. It is prepared by the destructive distillation of various trees of the family Pinaceæ. European tar is mainly prepared from the wood of *Pinus sylvestris* and *Larix sibirica* Ledeb. (*Pinus Ledebourii* Endl.), in Scandinavia, Eastern Germany, Poland, and Russia. Tar is also produced in America from species of *Pinus* and *Abies*.

Preparation.—Iron stills were introduced for the destructive distillation of wood in 1861 and are now largely used. The wood gas produced by the distillation may be used to heat the retorts, and in some parts of Germany and Switzerland it is used for illuminating purposes. In addition to the tar an aqueous distillate is obtained from which acetic acid, methyl alcohol, and acetone are prepared. A residue of wood charcoal remains in the retorts. When so distilled the stems yield about 14 per cent. and the roots 16 to 20 per cent. of tar.

The older method of preparation is described in *Pharmacographia* as follows :—

“Vast stacks of pine wood consisting chiefly of the roots and lower portions of the trunks (the more valuable parts of the trees being used as timber), and containing as much as 30,000 to 70,000 cubic feet, are carefully packed together, and then covered with a thick layer of turf, moss, and earth, beaten down with heavy stampers. The whole stack of billets is constructed over a conical or funnel-like cavity made in the ground, if possible on the side of a hill, this arrangement being adopted for the purpose of carrying on a downward distillation. Fire being applied the combustion of the mass of wood has to be carried on very slowly and without flame in order to obtain the due amount of tar and a charcoal of good quality. During its progress, the products, chiefly tar, collect in the funnel-like cavity, from which they are discharged by a tube into a cast-iron pan placed beneath the stack, or simply into hollow tree trunks. The time required for combustion varies from one to four weeks, according to the size of the stack.”

If this tar be redistilled it yields in turn methyl alcohol and acetone (about 10 per cent.), acetic acid, oil of tar (a reddish-brown liquid, S.G. 0.86 to 0.90, consisting of hydrocarbons and phenols), and pitch.

Characters.—Tar is a blackish semi-liquid with a characteristic odour and taste. The S.G. varies from 1.02 to 1.15. On keeping, tar becomes somewhat granular, probably owing to the crystallisation of pyrocatechin and other substances.

Chemical Tests.—Water triturated with tar acquires an acid reaction (distinction from coal tar). If 5 ml. of an aqueous extract, filtered through kieselguhr, are treated with 3 drops of a 0.1 per cent. solution of ferric chloride a red colour is produced. (*Note*: this test is also given by oil of cade, which like wood tar is acid to litmus.) Pine tar differs from oil of cade in that it gives a green colour when a light petroleum extract is shaken with solution of copper acetate and the upper layer diluted with ether.

Constituents.—A large number of substances have been isolated from wood tar. The list includes the following phenols and phenolic ethers: Phenol, C_6H_5OH ; cresols, $C_6H_4(CH_3)OH$; methyl cresols; catechol or pyrocatechin, $C_6H_4(OH)_2$; guaiacol (methyl catechol) and its homologues. Also the hydrocarbons benzene, toluene (methylbenzene), xylenes (dimethylbenzenes), mesitylene and pseudocumene (trimethylbenzenes), styrene (phenylethylene), naphthalene ($C_{10}H_8$), retene (*m*-methylisopropylphenanthrene), chrysene ($C_{18}H_{12}$), and paraffins.

Pine tar is characterised by the large amount of guaiacol and its homologues which are present. Other tars, such as those of the birch and beech, show considerable differences in composition. Official creosote is obtained from wood tar by distillation. It may be pointed out that beech tar was given as the source of the creosote of the 1914 Pharmacopœia.

Uses.—Tar is taken internally as a disinfectant and expectorant and is used externally, in the form of ointment or tar parogen, as a stimulating antiseptic in certain skin diseases.

TEREBINTHINA CANADENSIS

Canada Turpentine, Canada Balsam; F. Térébenthine du Canada; G. Canadischer Terpentin

Source.—Canada turpentine, or “Canada balsam” as it is often incorrectly called, is an oleo-resin obtained from the

stem of *Abies balsamica*, the balsam fir. It is collected in Eastern Canada and in the State of Maine in the U.S.A.

Collection.—The oleo-resin, which occurs only in the bark, is contained in schizogenous ducts and large cavities. As the cavities fill with secretion blister-like swellings develop on the trunk, and it is from these that the drug is collected. The pointed spout of a tin can is used to puncture the blisters, the oleo-resin then slowly flowing into the can. The collection is troublesome and is usually carried out by whole families who camp in the mountains for two months or so. The secretion ceases about the end of August. A good tree yields at most about 2.40 G. per day, and a collector with two young assistants can collect about 4,500 G. per day. At the camp the oleo-resin is filtered by the women into 5-gallon barrels.

Characters.—Canada turpentine when fresh is a pale yellow liquid with a slight, greenish fluorescence, and is of honey-like consistence. It has a pleasant, terebinthinate odour, and a somewhat bitter and acrid taste.

On exposure to air Canada turpentine becomes more viscous and finally forms a glass-like varnish, a property which renders it suitable as a microscopic mountant and as a cement for lenses. It has a refractive index of 1.518 to 1.521. Canada turpentine solidifies when mixed with about one-sixth of its weight of magnesium oxide moistened with water. The drug is soluble in benzene, chloroform, xylol, ether, and oil of turpentine. It is only partially soluble in alcohol.

Constituents.—The approximate composition of Canada turpentine is as follows: Volatile oil, 23 to 24 per cent.; α - and β -canadinolic acids, $C_{19}H_{30}O_2$, 48 to 50 per cent.; canadinic acid, $C_{19}H_{34}O_2$, 13 per cent.; canadolic acid, 0.3 per cent.; resene, 11 to 12 per cent. The bitter principle and the fluorescent substance have not yet been isolated. The fluorescence is very marked in filtered ultra-violet light.

Allied Drugs.—*Abies pectinata* yields the Continental drug Alsatian turpentine (F. *Térébenthine d'Alsace*; G. *Strasburger Terpentin*). It is interesting to note that the method of collecting this oleo-resin is almost identical with that used in Canada for Canada turpentine.

Pseudotsuga Douglasii Carr (*Abies Douglasii* Lind.) produces the American balsam of fir or Oregon balsam. It is said to be less viscous than Canada turpentine, and yields a sticky film of resin on exposure to air.

Tsuga canadensis Carr (*Abies canadensis* Michx.), the hemlock spruce, is sometimes given as a source of Canada turpentine. It is doubtful if any is now obtained from this plant.

Uses.—Canada turpentine is occasionally used as a pill excipient for very deliquescent salts. It is no longer an ingredient of the official flexible collodion, and is now mainly used in microscopy and as a cement for lenses.

OLEUM ABIETIS

Oleum Abietis, B.P. ; *Oil of Siberian Fir*, *Oil of Pine*

Source.—Oil of Siberian fir, or, as it is often known in commerce, Siberian “pine” oil, is distilled from the fresh leaves of *Abies sibirica*. It is produced in the Wjatka district of North-East Russia and to a lesser extent in Siberia.

Characters.—The oil is colourless or a very pale yellow. It has a pleasant, aromatic odour and pungent taste. The oil is strongly lævorotatory. It is soluble in an equal volume of alcohol (90 per cent.), or in 15 volumes of alcohol (80 per cent.).

Constituents.—The oil owes its odour mainly to borneol and terpineol esters (particularly bornyl acetate), which are present to the extent of about 29 to 43 per cent. It also contains about 3 to 4 per cent. of a hydrocarbon, santene, of the formula C_9H_{14} , and isomeric forms of pinene, camphene, and phellandrene. The official oil contains not less than 35 per cent. w/w and not more than 45 per cent. w/w of esters calculated as bornyl acetate, $C_{12}H_{20}O_2$.

Uses.—Oil of pine is used in inhalations and, on account of its pleasant odour and low price, in cheap perfumery.

PIX BURGUNDICA

Burgundy Pitch ; F. *Poix de Bourgogne*, *Poix des Vosges*, *Poix Blanche*, *Poix Jaune* ; G. *Burgundisches Pech*, *Tannenharz*

Source.—Burgundy pitch is a semi-solid, oleo-resinous secretion obtained from the stem of *Picea excelsa*, the Norway spruce. The drug was formerly collected and prepared in Scandinavia, the Black Forest, and in the Jura Mountains. The relatively small amounts now used are obtained from the Swiss side of the Jura Mountains, particularly from the forests of Soulec and Tramelan in the Delemont valley.

Collection and Preparation.—By means of an axe four incisions are made in the bark of each tree. These are made about 50 cm. from the ground and penetrate through the bark as far as the wood. In the following year the bark loosens as a result of growth and the oleo-resin, which gradually becomes semi-solid, collects between the bark and the wood. A cone-like receiver, made from bands of lime bark, is held below the incisions and the oleo-resin is scraped into it. The scraper is an instrument with sharpened edges which is fixed to the handle of the axe. The secretion, which at this stage contains about one-third of its weight of vegetable debris, is transferred to a sack and taken to the collector's hut. Here it is melted with water in a large copper vessel and then poured into a sack made of coarse cloth. This is supported over a trough cut in a tree trunk in which cold water is placed. The Burgundy pitch is pressed from the sack by means of a wooden lever weighted at one end. After kneading with water and then separating from this the drug is ready for the market.

Characters.—Burgundy pitch is an opaque, yellowish-brown or reddish-brown substance. It is brittle at ordinary temperature and breaks with a conchoidal (shell-like) fracture. Burgundy pitch resembles liquids in that it takes the form of the vessel in which it is stored, but its flow is extremely slow. It has an aromatic odour, and a sweetish, aromatic taste. Burgundy pitch is soluble in twice its weight of glacial acetic acid.

Constituents.—According to an analysis by Tschirch and Koch,* Burgundy pitch contains picea-pimarolic acid, $C_{18}H_{28}O_2$, 47 per cent.; picea-pimaric acid, $C_{20}H_{30}O_2$, 2 per cent.; picea-pimaric acid, $C_{12}H_{20}O_2$, 3 per cent.; juroresene 15 per cent.; volatile oil, 30 per cent.; bitter principles, water, and impurities 3 per cent.

Adulteration.—False Burgundy pitch is often sold. This is made by mixing colophony or "galipot" (a product of *Pinus maritima* resembling "scrape"), American or Bordeaux turpentine, and palm oil. A certain amount of water is stirred in to make the mixture opaque. It may be distinguished from the genuine drug by its incomplete solubility in twice its weight of glacial acetic acid.

Use.—Burgundy pitch is used to a limited extent in plasters.

* Tschirch and Koch, *Arch. Pharm.*, 1902, 240, 272.

Family CUPRESSACEÆ

A family consisting of 12 genera, and about 120 species. Important genera are *Juniperus*, *Cupressus*, *Thuja*, and *Callitris*. The family differs from the Pinaceæ in that the leaves and cone-scales are usually opposite or whorled, and the ovules erect.

JUNIPERI FRUCTUS

Baccæ Galbuli Juniperi; *Juniper Berries*; F. *Baies de Genièvre*; G. *Gemeiner Wacholder*, *Wacholderbeeren*

Source.—Juniper berries are the dried ripe fruits of *Juniperus communis*, an evergreen shrub or small tree. They are collected in Italy, Hungary, E. Prussia, Poland, Thuringia, and Sweden. Generally speaking, the berries from the more southern countries contain the most oil.

Characters.—The female cones consist of scales arranged in whorls of three. The upper whorl bears one ovule on the upper surface of each scale. Below the ovuliferous scales are from 2 to 4 whorls of bracts. After fertilisation, which occurs in May, the ovuliferous scales become fleshy and grow together to form a berry-like fruit (galbulus). During its first year the galbulus remains green, but in the autumn of the following year it ripens, the outer surface having a deep purplish colour and a bluish-grey bloom.

The berries become somewhat darker and shrivel slightly on drying. They are about 7 to 10 mm. in diameter. The apex shows a triradiate mark and depression indicating the sutures of the three fleshy scales. At the base there are usually six, small, pointed bracts arranged in two whorls, but occasionally three or four such whorls are found.

A traverse section of the fruit shows a thin, outer skin or epicarp, a yellowish-brown, pulpy mesocarp, and three seeds. The seeds lie close together in the centre of the fruit and are hard and woody. Partly embedded in the hard testa of each seed are large oleo-resin glands. These usually number from 4 to 8 on the outer side of the seed, and 1 or 2 on the inner. Smaller oil glands occur in the pulp. In young fruits the glands appear to contain more oil than resin, but in old fruits the reverse is the case. The belief, formerly held, that immature fruits yield more oil than mature ones has been disproved. The drug has a pleasant, somewhat terebinthinate odour, and a sweetish taste.

Constituents.—Juniper berries contain volatile oil (see below); invert sugar (about 33 per cent.); resin (about

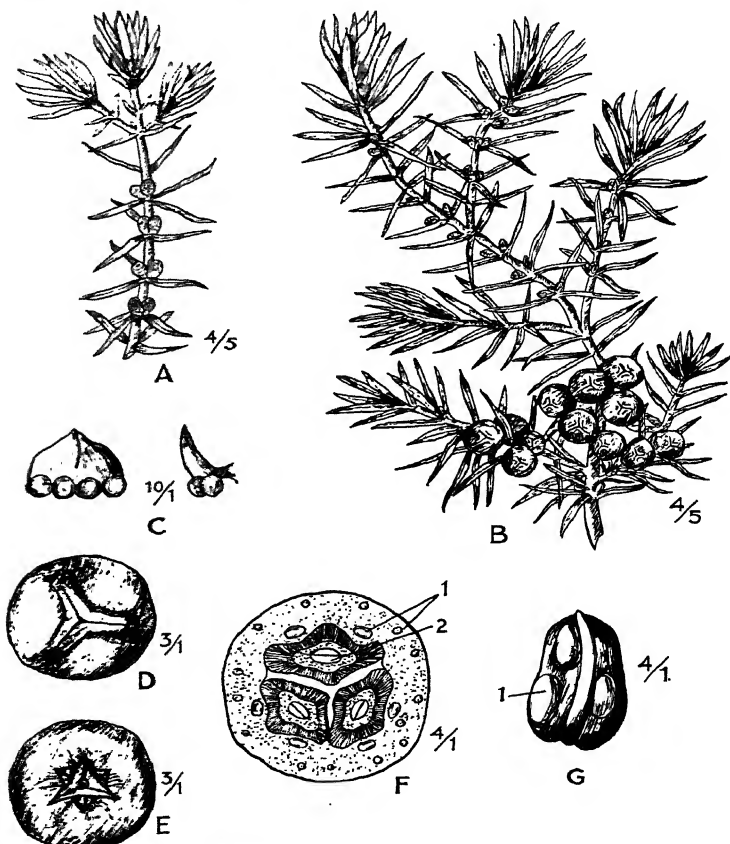


FIG. 67.—*Juniperus communis*. A, branch with male cones; B, branch with berries; C, scales of male cones; D, fruit from above; E, fruit from below; F, transverse section of ripe fruit; G, seed. 1, oil gland; 2, cotyledons. (A and C after Thoms, B after Gilg, F after Tschirch, G after Berg.)

10 per cent.); a bitter principle, organic acids and their salts, and wax.

Uses.—Juniper berries yield oil on distillation and leave a

residue, which on extraction with water and subsequent evaporation, yields "Roob or Rob of Juniper" (*Succus Juniperi*), a preparation much used in Germany. Juniper berries are also used in making certain varieties of gin.

OLEUM JUNIPERI

Oleum Fructus Juniperi; Oil of Juniper Berries; F. *Huile Volatile de Genièvre*; G. *Wacholderöl, Wacholderbeeröl*

Source and Preparation.—Oil of juniper is the oil obtained by distillation and rectification from the ripe fruits of *Juniperus communis*. A little oil is distilled in England, but it is difficult to compete in price with the Continental producers, who have a ready supply of wild berries, cheap labour, and such a ready market for *Succus Juniperi* that the oil is of the nature of a by-product. Schimmel gives the average yields of oil from the berries of different countries as follows: Italian, 1 to 1.5 per cent.; Bavarian, 1.2 per cent.; Hungarian, 0.8 to 1 per cent.; Polish, 0.9 per cent.; Thuringian, 0.76 per cent.; East Prussian, 0.6 per cent.; Swedish, 0.5 per cent.

According to Parry, much of the oil met with in commerce is probably not normal in composition, but is obtained as a by-product in the manufacture of gin and similar spirits.

History.—Juniper berries have been used in medicine from very early times. The oil was distilled by Schnellenberg in 1546.

Characters.—A colourless or pale yellowish-green liquid having a characteristic odour and a bitter, aromatic taste. S.G. 0.865 to 0.890; optical rotation -3° to -20° ; refractive index 1.475 to 1.488. Soluble, when freshly distilled, in four parts of alcohol (95 per cent.). The solubility decreases and the specific gravity increases with age.

Constituents.—Oil of juniper contains the terpenes α -pinene and camphene; the sesquiterpene cadinene; at least two terpene alcohols, one of which is terpineol, and traces of esters. On cooling old samples of oil of juniper a crystalline substance, "juniper camphor," is deposited.

Adulterants and Substitutes.—The purity of oil of juniper is judged to a considerable extent by the size of the pinene and cadinene fractions which are obtained when it is fractionally distilled.

Oil of Juniper Wood of commerce is usually a mixture of turpentine and juniper berry oil.

Oil of Juniperus phænicea berries differs slightly in physical constants from the genuine oil. It is dextrorotatory ($+3^{\circ}$ to $+5^{\circ}$).

Oil of Juniperus Oxycedrus berries is lighter than that of *J. communis*. It has a S.G. of 0.850 to 0.856.

Uses.—Oil of juniper is used as a stimulating diuretic.

SABINÆ CACUMINA

Sabina ; *Savin Tops* ; *F. Sabine* ; *G. Sevenkraut, Sadebaumspitzen*

Source.—Savin tops are the young shoots of *Juniperus Sabina*. The savin is a woody, evergreen shrub about 2 to 6 m. in height. It grows wild in the mountains of Austria, Switzerland, Italy, France, and Spain, and is commonly cultivated in Britain.

Characters.—The leaves are imbricated, sessile, more or less adnate to the stem, and usually opposite and decussate. The shape and size of the leaves differ very considerably on different parts of the plant. The young leaves are oval or hexagonal and closely appressed to the stem, but as they grow older they become rhomboid-lanceolate, the apex becoming more pointed and diverging more and more from the stem. Savin also has a permanent juvenile form, the variety *tamariscifolia* Aiton, with needle-like leaves. Each leaf has a depression on its dorsal surface, below which is a large oil gland in the mesophyll. This oil gland is oval in young leaves but more elongated in old ones.

Savin is monœcious or diœcious. The female cones have four ovuliferous scales and about 3 to 10 pairs of sterile bracts. The galbulus is blue-black, globular, and about 5 to 7 mm. in diameter. It has a recurved stalk, and its outer surface shows signs of the incomplete fusion of the constituent scales. The seeds are egg-shaped and vary in number from 1 to 4.

Constituents.—Savin tops contain from 3 to 5 per cent. of volatile oil (see below), also tannin and resin.

Substitutes.—The most likely substitutes and adulterants are as follows :—

Juniperus phænicea.—Shoots of this species may be identified by the spirally arranged leaves, which in transverse section show large sclerenchymatous cells in the mesophyll (such cells are absent in *J. Sabina*).

Juniperus thurifera has opposite and decussate leaves as in savin, but possesses sclerenchymatous cells in the mesophyll of the leaves.

Juniperus virginiana, the American red cedar, is sometimes



FIG. 68.—*Juniperus Sabina*, showing different forms of leaves. (Newman.)

known as savin in America. It is frequently cultivated in Europe. The leaves have stomata arranged in a transverse band below the oil gland, whilst in *J. Sabina* the stomata are in two longitudinal bands on either side of the oil gland.

Cupressus sempervirens (Cypress) and *Thuja occidentalis*

(Arbor-vitæ) are commonly cultivated in Britain. Their twigs may be distinguished from those of savin (which have a rounded quadrangular shape) by their flattened shape.

OLEUM SABINÆ

Source.—Oil of savin is the oil distilled from the fresh twigs of *Juniperus Sabina*.

Characters.—A colourless or pale yellow liquid with a characteristic, unpleasant odour, and bitterish, aromatic taste. S.G. 0.907 to 0.930; optical rotation, $+38^{\circ}$ to $+63^{\circ}$; refractive index, 1.472 to 1.480; ester value, 105 to 140; ester value (after acetylation), 125 to 155.

Constituents.—The chief constituents are the terpene alcohol, sabinol, and its ester, sabinyl acetate. According to Schimmel (1895), the oil contains about 10 per cent. of the free alcohol and 40 per cent. of the ester (cf. the ester values before and after acetylation given above). The oil also contains a number of terpenes (sabinene, terpinene, pinene), the sesquiterpene, cadinene, and smaller quantities of acids, alcohols, aldehydes, etc.

Substitute.—French oil of savin is frequently prepared from *J. phœnicea* and *J. thurifera*. It contains very little sabinyl acetate (ester value 0 to 26), and little free sabinol (ester value after acetylation 5 to about 40). It has a lower specific gravity and a lower optical rotation than the genuine oil.

Uses.—Oil of savin is a powerful irritant both internally and externally. It has a very limited employment as a uterine stimulant and emmenagogue, but has not been official in Britain since the B.P. of 1885.

OLEUM CADINUM

Oleum Cadinum, B.P.; *Pix Juniperi*; *Oil of Cade*, *Juniper Tar Oil*; *F. Huile de Cade*; *G. Kadeöl*

Source.—Oil of cade is an empyreumatic volatile oil obtained by the destructive distillation of the woody portions of *Juniperus Oxycedrus*. It is prepared in the South of France, particularly in the provinces of Gard (near to Alais), Var, and Alpes Maritimes. Nîmes and Avignon are important centres for its distribution.

Preparation.—Old wood of *Juniperus Oxycedrus* gives a better yield of oil than the wood of young trees. Other species of juniper appear to be sometimes used. In the older method of preparation the wood, which is cut into small billets, is placed in a cast-iron pot. This is then inverted over a concave stone slab in the centre of which is an opening fitted with a pipe, through which the products of the distillation pass to a receiver. A fire, made from the smaller branches, is made to envelop completely the iron pot, and a high temperature is maintained until the distillation is complete. The distillate is allowed to stand for at least fifteen to twenty days, when it separates into three layers: (i) a lower layer of tar; (ii) an intermediate aqueous layer; and (iii) an upper oily layer. The last is separated and constitutes oil of cade.

Oil of cade is also prepared by allowing the wood to burn slowly for several days in a large, brick kiln. This has a sloping floor and a gutter to carry away the liquid products. Oil of cade separates from these on standing.

If the wood of *J. Oxycedrus* is submitted to ordinary steam distillation it yields from 1.6 to 3.4 per cent. of volatile oil. Much of this oil no doubt passes over during the destructive distillation described above and acts as a solvent for heavier, tar-like substances.

Characters.—Oil of cade is a reddish-brown or blackish, oily liquid. Odour empyreumatic; taste, aromatic, bitter, and acid. It is less viscous than wood tar and has a lower specific gravity (0.975 to 1.010). Oil of cade is completely soluble in all proportions in chloroform, amyl alcohol, oil of turpentine, and glacial acetic acid, or in three volumes of ether. In cold alcohol (90 per cent.) it only partially dissolves, but in hot alcohol it is almost completely soluble. Water shaken with it remains almost colourless, but becomes acid to litmus. This solution gives a red colour with 3 drops of a 0.1 per cent. solution of ferric chloride. In its reaction to litmus and in the ferric chloride test it resembles wood tar. Among other tests the Pharmacopœia gives a test for absence of pine tar oil.

Constituents.—The chief constituents of oil of cade are two sesquiterpenes, one, cadinene, boiling at 270°–275°, and the other (which is present in greater amount) at 250°–260°. The oil also contains phenolic compounds (guaiacol, ethyl-guaiacol, creosol), and acetic acid and its homologues.

Adulteration.—The name *Huile de Cade vétérinaire* is sometimes used in France for the upper layer which may be

separated from pine tar. Both this and pine tar oil, prepared from tar by distillation, are said to be used for adulteration.

Uses.—Oil of cade has been used for veterinary purposes for centuries, but it was not until about 1870 that it was prescribed for skin diseases, such as psoriasis and eczema, for which it is now used.

SANDARACA

Sandarac, Gum Juniper ; F. Sandarague ; G. Sandarac

Source.—Sandarac is a resin obtained from the stem of *Callitris quadrivalvis*, a tree 6 to 12 m. in height, which is found in North and North-West Africa and in Spain. It is collected in Africa by the natives and shipped from Mogadore, Casablanca, and Nazagan.

Collection.—The bark contains schizo-lysigenous cavities full of oleo-resin. Some of the drug is obtained by natural exudation, some by making incisions in the bark. The secretion gradually hardens and is then picked from the stem.

Characters.—Sandarac occurs in small tears about 0.5 to 1.5 cm. in length. These usually have an elongated, stalactitic or cylindrical shape, globular or pear-shaped tears (such as are found in mastich) being relatively rare. The surface is covered with a yellowish dust, but the interior is more or less transparent, and on holding the tears up to the light small insects can frequently be seen imbedded in them. The drug is easily powdered and when chewed remains gritty, showing no tendency to form a plastic mass (distinction from mastich). The drug has a faint, terebinthinate odour, which is increased by warming, and a somewhat bitter taste. It is almost completely soluble in alcohol (90 per cent.) ; completely soluble (except for the insects) in dehydrated alcohol and in ether.

Constituents.—According to Tschirch and Wolff * sandarac resin consists of sandaracopimaric acid (inactive pimaric acid) which may be obtained in acicular crystals to the extent of 85 per cent. ; sandaracinic acid ; sandaracinolic acid ; and sandaracoresene. The drug also contains a bitter principle and 0.26 to 1.3 per cent. of volatile oil.

Allied Drug.—*Australian sandarac*, which is collected in New South Wales, Central and Western Australia, from

Tschirch and Wolff, *Archiv. Pharm.*, 244, 684 ; abstracted *Y. B. Pharm.* 144.

Callitris verrucosa and other species, is also imported. This drug contains more volatile oil than the African variety and is therefore softer and more aromatic. The tears are usually larger than those from *C. quadrivalvis*.

Uses.—Sandarac is used as a varnish for light woods, and in pill varnish.

Order GNETALES

Family EPHEDRACEÆ

EPHEDRA

Ephedra, Ma-Huang

Source.—Various species of *Ephedra* are used as a source of the alkaloid ephedrine. The Chinese ephedras, *Ephedra sinica* (Tsaopen Ma-huang) and *Ephedra equisetina* (Mupen Ma-huang), are imported in considerable quantities, but the alkaloid is also present in other species, e.g. in *E. distachya*, *E. intermedia*, and *E. Gerardiana*. The seeds of *Sida cordifolia*, which contain about 0.4 per cent. of ephedrine, have also been suggested as a possible commercial source of the alkaloid.

The *Ephedra* species vary from dwarf bushes a few inches in height to large shrubs or even a small tree (*E. triandra*). Seventeen species are known in the Old World, six in North America (California, Nevada, Utah, Arizona, and Mexico), and eight in South America.

History.—Ma-huang was known to the Chinese over five thousand years ago. The alkaloid ephedrine was isolated by Nagai in 1887, but it is only within the last decade or so that it has come into extensive use.

Collection.—The drug is collected in the autumn, this being important as the amount of alkaloid present shows considerable variation at different seasons.

The drug is imported in bales. It consists of slender, more or less broken aerial stems which are woody and usually branch only at the base.

Characters.—The stems of the ephedras bear numerous, fine, longitudinal ridges. The leaves are small, connate at the base, and are usually in whorls of two (less commonly in whorls of 3 or 4) and decussate. The following notes on the morphology of three important Chinese species are largely derived from papers by Small,* Short,† and Liu and Read.‡

* Small, Y. B. Pharm., 1928, 163.

† Short, Y. B. Pharm., 1928, 182.

‡ Liu and Read, J. Amer. Pharm. Ass., 1929, 18, 328.

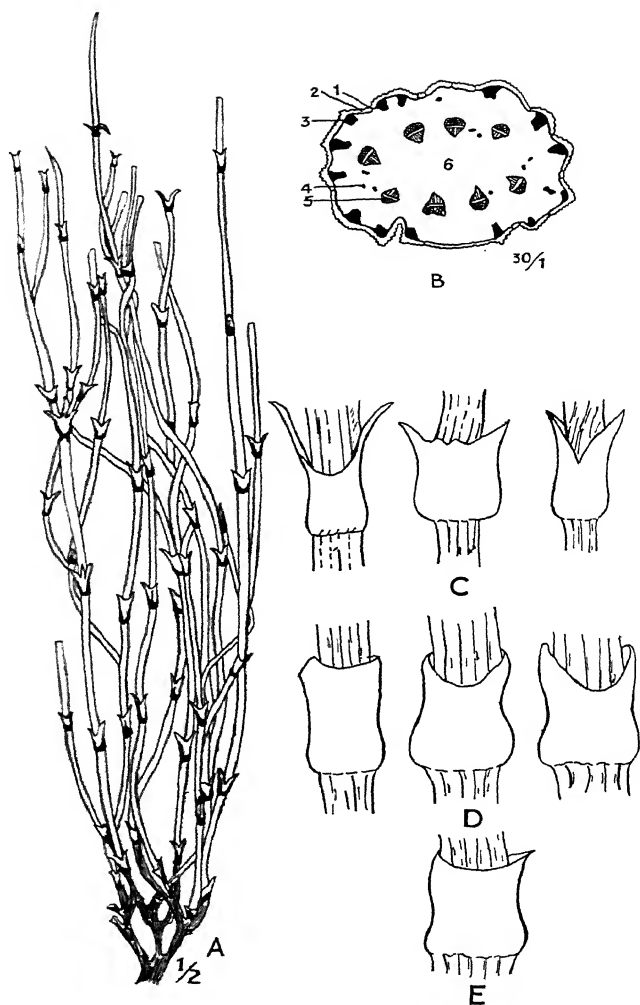


FIG. 69.—*Ephedra*. A, a typical sample of *Ephedra sinica*; B, a transverse section of a young stem of same, 1.25×0.9 mm.; C, leaves of *E. sinica*; D, leaves of *E. equisetina*; E, leaf of *E. distachya*. 1, stoma; 2, epidermis; 3, group of sclerenchymatous fibres at the apex of a rib; 4, fibres; 5, pericycle fibres; 6, pith. (A and B after Short; C, D, and E after Small.)

(1) *Ephedra sinica* Stapf. (also known as *E. vulgaris* and *E. vulgaris* var. *helvetica*).—The stems are about 30 cm. in length, ashy greyish-green in colour, and slightly rough. The diameter at the lowest green node is about 1 or 2 mm., while the internodes are about 3 to 6 cm. long. The leaves, which are about 4 mm. long, have a subulate, recurved apex; the lamina is whitish and the base reddish-brown.

In transverse section the young stem (Fig. 69, B) shows from six to ten bundles. Small groups of fibres occur below the ridges (9 to 20 in a group), a few groups (usually of 2 to 6) of fibres in the cortex and a few isolated fibres or small groups of 2 or 3 fibres in the pith. The pith is otherwise unligified.

(2) *Ephedra equisetina* Bunge (also known as *E. monosperma* Gmel. and *E. monostachya* L.).—The stems are very woody and much branched, 25 to 200 cm. in length, smooth and ashy yellowish-green in colour. The internodes are shorter than *E. sinica*, being about 1 to 2.5 cm. in length. The apex of the leaves is shorter than the cup and not recurved. The leaves are of a brownish-purple colour, the lower ones tending to go black.

Transverse sections show that the number of bundles in the stem is not constant (usually about ten). The annual rings tend to be more pronounced than in *E. sinica*, and the outer xylem has a characteristically lobed outline.* Cortical and pericyclic fibres are found but no perimedullary ones. The pith is lignified.

(3) *Ephedra distachya*.—The stems are slightly woody and branching takes place from the upper and lower parts of the main stem. Stems about 37 cm. long, rough and greenish-yellow in colour. Internodes 2.5 to 6 cm. in length. Leaf apex short but acute (see Fig. 69, E), and often fissured at the base.

The number of bundles, which is eight, is constant. There are no cortical or perimedullary fibres, but the pith is lignified.

Ephedra, when dry, has little odour. The taste is slightly bitter.

Constituents.—Ephedrine (*l*-ephedrine) was first isolated from *Ephedra vulgaris* (*Ephedra sinica*) by Nagai in 1887, and was synthesised by Eberhardt in 1920. The drug Ma-huang contains a number of closely related alkaloids. Nagai and Kanao† recognise five, namely, ephedrine or *l*-ephedrine (colourless crystals, m.p. 40°, $[\alpha]_D -6.3^\circ$), *d*-iso-ephedrine

* Cf. Small, Y. B. *Pharm.*, 1928, p. 165, and Fig. 6 B.

† Nagai and Kanao, *J. Pharm. Soc. Japan*, 1928, 48, 101.

(m.p. 118°), *l*-methylephedrine (m.p. 87°), nor-*d*-isoeephedrine (m.p. 78°), and *d*-methylisoeephedrine (m.p. 28°). Ephedrine has the formula $C_6H_5.CH(OH).CH(NH.CH_3).CH_3$, and is therefore α -hydroxy- β -methylaminopropylbenzene. The official salt, the hydrochloride, forms colourless crystals, m.p. 217° to 220°.

Read and Liu * have shown that the alkaloidal content of ephedra is greatest in the autumn, the percentage decreasing to about one-third in the spring. Determinations performed by Read and Feng † on Indian ephedras supplied by the Forestry Department at Dehra Dun gave the following results :—

Species.	Total Alkaloid, per cent.	Proportion of Ephedrine in Total Alkaloid, per cent.
<i>E. sinica</i> ..	1.315	80-85
<i>E. equisetina</i> ..	1.754	85-90
<i>E. Gerardiana</i> ..	1.65-1.70	70-80
<i>E. intermedia</i> ..	1.155	30-40

The amount of ash yielded by different ephedras is variable. and Read record the following :—

	Per cent.	Per cent.
<i>E. sinica</i> .. Total ash	9.77	acid insoluble ash 2.23
<i>E. equisetina</i> ..	6.55	.. .. 0.28
<i>E. distachya</i> ..	8.20	.. .. 0.42

Uses.—Ephedrine is used for the relief of asthma and hay fever. Its action is more prolonged than that of adrenaline, and it has the further advantage that it need not be given by injection but may be administered by mouth.

* Read and Liu, *J. Amer. Pharm. Ass.*, 1928, 17, 339.

† Read and Feng, *J. Amer. Pharm. Ass.*, 1928, 17, 1189.

CHAPTER XVIII

Phylum ANGIOSPERMÆ ; Subphylum MONOCOTYLEDONS

Order GLUMIFLORÆ

A LARGE order including the families Gramineæ and Cyperaceæ. The inflorescence is large and compound, and usually composed of small spikes or spike-like cymes. The flowers are small, with little or no perianth, a single whorl of three stamens, and a one-seeded ovary. The fruit is a caryopsis or nut.

Family GRAMINEÆ

A family including about 500 genera, and 4,000 species. The members are almost universally distributed, and many are of great economic importance. The following yield important foodstuffs: *Zea Mays* (maize), *Saccharum officinarum* (sugar cane), *Oryza sativa* (rice), *Avena sativa* (cultivated oat), *Secale cereale* (rye), *Triticum sativum* (cultivated wheat), and *Hordeum sativum* (cultivated barley). Grass oils are very largely used in perfumery, particularly for scenting soap. They include—Ceylon Citronella oil (from *Cymbopogon nardus* Rendle, and other species), Java Citronella oil (*C. nardus*), Lemon Grass oil (*C. flexuosus* and *C. citratus*), and oil of Vetiver (*Vetiveria zizanioides* Stapf.).

The oat, *Avena sativa*, is an annual herb which will be familiar to all students of botany. The inflorescence is an open panicle of spikelets, each spikelet being stalked and usually consisting of two flowers with their accompanying paleæ and glumes. The lower palea bears a twisted awn. The fruit is a somewhat elongated caryopsis which readily separates from the enclosing paleæ and glumes.

Oatmeal and oatmeal gruel appear to have no special therapeutic action but form a wholesome food. They contain carbohydrate, oil, and protein matter.

The wheat, *Triticum vulgare*, is an annual plant with an inflorescence of sessile spikelets arranged in two rows on a jointed rachis. Each spikelet consists of three or four fertile flowers, the paleæ of which are usually without awns. A variety, bearded wheat, in which long awns are developed, may be distinguished from barley by the shape of the spike and by the arrangement of the spikelets (see below). The fruit is an ovoid caryopsis which can be separated from the paleæ without difficulty.

Wheat flour contains about 75 per cent. of starch, the characters of which are described on p. 91, and about 9-14 per cent. of proteins.

The barley, *Hordeum distichon*, is an annual which, at first glance, resembles bearded wheat. The single-flowered, sessile spikelets are arranged alternately in groups of three on a jointed rachis. Only one flower of each group is fertile and the resulting ear is more elongated and less crowded with fruits than the ear of wheat. The paleæ bear long awns and fuse with the caryopsis so that they cannot be removed entire. In addition to the two-rowed barley, *Hordeum distichon*, four and six-rowed barleys, derived from *Hordeum vulgare*, are cultivated.

Barley contains about 60 per cent. of starch, 7 per cent. of sugars, protein, and oil. Pearl barley (*Hordeum Decortiatum*, B.P. 1885) is a milled and highly polished barley, rich in starch but relatively poor in protein. The decoction, barley water, has been in use since the time of Hippocrates.

RHIZOMA GRAMINIS

Agropyrum, *Triticum* ; Couch Grass, Quitch, Twitch ;
F. Rhizome de Chiendent ; G. Queckenwurz

Source.—The couch grass, *Agropyrum repens* Beauvois (*Triticum repens* Linn.), is indigenous to Europe, but has been introduced into America and is now a troublesome weed in both continents. The drug is collected in England and in Germany.

History.—Couch grass or a similar grass, perhaps *Cynodon Dactylon*, was used by the ancients as a remedy for urinary disorders. It has been widely used on the Continent and is still official in many pharmacopœias although deleted from the British Pharmacopœia.

Collection and Preparation.—In autumn and spring the long slender rhizomes are removed by ploughing and harrowing. They are washed, deprived of their roots as far as possible, dried, and cut into small pieces.

Characters.—The drug occurs in pieces from 4 to 12 mm. in length and from 1 to 2.5 mm. in diameter. The outer surface is straw-yellow in colour, glabrous, and longitudinally furrowed. At the nodes, which are present on some of the pieces, are the remains of encircling leaf-bases and root scars or even roots which, if undamaged, may attain a length of 5 cm. and a diameter of 0.5 mm.

In section * the rhizome shows a strongly lignified epidermis, a cortex of 10 to 16 rows of parenchymatous cells containing irregular masses of carbohydrate, and a number of leaf-trace bundles. Within the cortex lies a row of endodermal cells with U-shaped thickening, a ring of 10 or 12 fibro-vascular bundles, and 8 or 10 rows of parenchyma. The pith is broken or absent in the internodes.

Odour, slightly aromatic; taste, sweetish.

Constituents.—Couch grass contains about 5 per cent. of the carbohydrate, tritacin. This substance is slightly soluble in water and resembles inulin in yielding fructose on hydrolysis. It occurs in other graminaceous plants. Two glycosides have also been reported,† one of which yields vanillin on hydrolysis. As the epidermal cells are strongly silicified the ash contains much silica. A few small starch grains are present, but are not sufficient to cause a marked change in colour when a section is treated with iodine.

Adulteration.—Small (1919) showed that there was then very little true couch grass on the market. Bermuda grass or dog grass (*Cynodon Dactylon* Persoon) being substituted. The rhizome of this grass, which is said to resemble couch grass in medicinal properties, may be easily distinguished from the genuine drug by the fact that its section is blackened by solution of iodine owing to the presence of abundant starch.

Order SPADICIFLORÆ

The plants included in this order are herbs, shrubs, and trees belonging to the families Palmæ, Araceæ, and Lemnaceæ. Speaking generally the Palmæ are trees, the Araceæ are large

* Cf. Thoms, *Handbuch der Pharmazie*, V, p. 480, Fig. 296.

† Alsberg, Viehover, and Yewey, *J. Amer. Pharm. Ass.*, 1919, 469.

herbs or shrubs of very varied habit, and the Lemnaceæ are small aquatics. The inflorescence consists of a spike or spadix, which is generally enclosed in a large bract or spathe. The flowers are small, unisexual or bisexual. Perianth absent or, if present, not petaloid. The ovary is superior and the fruit usually a berry, drupe or nut.

Family PALMÆ

A family of about 140 genera and 1,200 species. Widely distributed in the tropics and subtropics. Mostly trees with an unbranched stem bearing a crown of large, often branched, leaves. The flowers are usually unisexual and regular, consisting of two trimerous whorls of small perianth leaves, six stamens, and three superior carpels. The carpels may be free or united and develop into a berry, drupe or nut. The seeds contain a very small embryo but abundant endosperm.

The following species are of economic importance: *Phœnix dactylifera* (the date palm), *Serenoa sorculata* (the fruit of which forms sabal or saw palmetto), *Metroxylon Rumphii* (sago), *Dæmonorops* spp. (dragon's blood), *Areca Catechu* (betel nuts), *Elais guineensis* (palm oil), *Cocos nucifera* (coconut), *Phytelephas* spp. (vegetable ivory), and *Copernicia cerifera* (carnauba wax).

SANGUIS DRACONIS

Dragon's Blood ; F. *Sang-dragon* ; G. *Drachenblut*

Source.—Dragon's blood of present-day commerce, better described as East Indian dragon's blood, is a red resin prepared from the fruits of various species of *Dæmonorops*, particularly *Dæmonorops propinquus* and *D. ruber*. These are palms, found in Sumatra, Borneo, the islands of the Sunda chain, and in Penang, which climb by means of very long flexible stems and thorny leaves.

History.—The dragon's blood known to Dioscorides and Pliny was produced in Socotra, and appears to have been obtained from a liliaceous plant, *Dracæna Ombet*. Early writings on the East Indies contain no mention of the drug of present-day commerce, and the drug used by the Chinese was the African product. The first clear account of the production of dragon's blood in the East Indies (Palembang) was given by Rumphius in 1747.

Collection and Preparation.—The trilocular ovary develops into a one-seeded fruit about the size of a large cherry, which is surrounded by a layer of hard, imbricate scales. When mature the scales can hardly be seen as they are thickly coated with red resin. The fruits are gathered, and shaken or beaten in a sack or basket to separate the resin. The latter is sifted to remove fruit scales, etc., and is softened, either by exposure to the sun or by the vapour from boiling water. While soft it is made into lumps, flat cakes, or sticks. According to Treub (1891), it is generally mixed with the milky juice of *Garcinia parviflora* (Guttiferae).

Characters.—Dragon's blood occurs in flattened or rounded masses ("saucer" and "lump" dragon's blood), sometimes several pounds in weight; also in cylindrical sticks ("reed" dragon's blood) from 20 to 30 cm. long and from 1.5 to 3.0 cm. in diameter. The drug is imported in cases, the "saucer" wrapped in leaves, the lump in sacking or reed matting, and each stick of "reed" in a leaf of a fan-palm of the genus *Licuala*.

Good samples of the drug are homogeneous and dark red in colour, but inferior samples, which are known as "seedy" dragon's blood, are heterogeneous and paler in colour since they contain a considerable quantity of the fruit scales. The exterior of the lumps frequently shows marks left by the sacking or matting, and where they have rubbed against one another the surface is covered with a crimson powder. The drug has little odour or taste.

Constituents.—According to Tschirch,* dragon's blood consists of a red resin (dracoresin), about 56.8 per cent., which is a mixture of esters derived from a resin alcohol (dracoresinotannol) and benzoic and benzoylactic acids; a bright yellow amorphous resene (dracoresene), 13.58 per cent.; a white amorphous substance (draco-alban), 2.5 per cent.; insoluble vegetable debris, 18.4 per cent.; and ash, 8.3 per cent.

In commercial samples the insoluble vegetable and mineral matter frequently exceeds the percentages given above, and from 40 to 50 per cent. of alcohol-insoluble matter is not uncommon.

Allied Drugs.—The "East Indian" drug described above is the only one now commonly met with in commerce. Socotrine dragon's blood ("Zanzibar drop"), the product of

* Tschirch, *Harze und Harzbehälter*, 1900, p. 189.

Dracana Ombet, and West Indian dragon's blood, from *Pterocarpus draco*, are now rarely seen.

Uses.—Dragon's blood is used for colouring mahogany varnishes, for staining marble, and in the preparation of lacquers and dentifrices.

ARECÆ SEMINA

Areca Nut, Betel Nut; F. Noix d'Areca; G. Arekanüsse, Betelnüsse

Source.—Areca nuts are the seeds of *Areca Catechu*, a feather-palm 15 to 17 m. high, which is cultivated in tropical India, Ceylon, the Malay States, South China, the East Indies, the Philippine Islands, and parts of East Africa (including Zanzibar and Tanganyika). Large quantities are exported from Madras, Singapore, Penang, and Ceylon.

History.—Areca was known in China under the name *pin-lang* (probably a corruption of the Malay name for the tree *pinang*) from at least 100 B.C. Immense quantities have been consumed in the East from very early times in the form of a masticatory known as betel, which consists of a mixture of areca nuts, the leaves of *Piper Belle*, and lime. The value of areca as a tænicide was also known in the East and, after successful trials by European physicians, it was included in the *Additions to the B.P. 1867*, published in 1874.

Collection and Preparation.—The unilocular ovary, containing a single anatropous ovule, develops into an orange-yellow, egg-shaped fruit about 5 cm. in length, which is crowned with the remains of the stigmas. The thick pericarp is fleshy when young, but later develops into longitudinally running fibres, the outer region being composed of finer fibres than the inner. Within the pericarp lies a single seed, with an ill-defined testa, which partly adheres to the pericarp. The fruits, of which about 100 are annually borne on each tree, are detached by means of bamboo poles, and the seeds extracted. The latter, before exportation, are usually boiled in water containing lime, and dried.

Characters.—The areca nut is about 2.5 cm. in length and rounded conical in shape. Patches of a silvery coat, the inner layer of the pericarp, occasionally adhere to the testa. The deep brown testa is marked with a network of depressed, fawn-coloured lines. The seed is very hard, has a faint odour when broken, and an astringent, somewhat acrid taste.

Sections of the seed show dark brown, wavy lines (folds of testa and perisperm) extending into the lighter-coloured interior (ruminate endosperm). At the flattened end of the seed is a small embryo. If the folds mentioned above are examined microscopically it will be seen that each contains a vascular bundle, which is surrounded by a thin layer of perisperm. These bundles anastomose and form the reticulations visible on the outside of the seed, later joining the fibro-vascular bundles of the funiculus.

Constituents.—Areca contains a number of alkaloids which are reduced pyridine derivatives. Of these, arecoline (methyl ester of arecaine), arecaine (N-methyl guvacine), and guvacine (tetrahydronicotinic acid) may be mentioned. Only arecoline, which is present to the extent of 0.1 to 0.5 per cent., is medicinally important. Ether extraction yields about 14 per cent. of fat, consisting mainly of the glycerides of lauric, myristic, and oleic acids. A subsequent extraction with alcohol yields about 15 per cent. of amorphous, red tannin matter (areca red) of phlobaphene nature.

Uses.—Powdered areca is used as a vermifuge for dogs. Areca charcoal, which is very hard, is sometimes used in dentifrices. Arecoline hydrobromide has been used for colic of horses, and in human medicine as a tænicide and as a myotic.

Order LILIIFLORÆ

An order of six families, including the Liliaceæ, Amaryllidaceæ, and Iridaceæ. Mainly perennial herbs having a bulb, corm or rhizome. The flowers are hermaphrodite, regular or zygomorphic, and of the floral formula $P\ 3+3, A\ 3+3, \text{ or } 3+0, G(3)$. In the families considered below the perianth is petaloid; the ovary superior (Liliaceæ) or inferior (Iridaceæ); and the fruit a capsule or berry.

Family LILIACEÆ

A widely distributed family of about 200 genera and 2,600 species. Mostly perennial herbs with a rhizome or bulb. The flowers usually have six stamens, and a superior (rarely semi-inferior) trilocular ovary with numerous anatropous ovules attached to axile placentas. The fruit is a loculicidal or septicidal capsule, or a berry.

Of the eleven subfamilies recognised by Engler the following contain medicinally important species :—

Subfamily **Melanthioideæ**, *Veratrum* spp. (white hellebore rhizome and American veratrum); *Colchicum autumnale* (colchicum corm and seeds); *Schœnocaulon officinale* (cevadilla seed).

Subfamily **Asphodeloideæ**, *Aloe* spp. (aloes).

Subfamily **Lilioideæ**, *Urginea* spp. (urginea and squill).

Subfamily **Asparagoideæ**, *Convallaria majalis* (lily of the valley flowers).

Subfamily **Smilacoideæ**, *Smilax* spp. (sarsaparillas).

Owing to the close similarity between the American and European veratrum these drugs will be considered together.

VERATRI VIRIDIS RHIZOMA

American Veratrum, American Hellebore, Green Hellebore ;
F. *Vératre Vert* ; G. *Grüner Germer*

VERATRI ALBI RHIZOMA

White Hellebore ; F. *Racine d'Ellebore Blanc* ; G. *Weisse Nieswurzel, Germer*

Source.—American hellebore consists of the dried rhizome and roots of *Veratrum viride* Aiton, a plant found abundantly in damp situations from Canada to Georgia, where it is often known as swamp hellebore. The drug is chiefly obtained from North Carolina, Virginia, Illinois, and Michigan.

White hellebore consists of the dried rhizome and roots of *Veratrum album* Linn. It is found in Central and Southern Europe in mountainous but well-watered surroundings, and throughout Northern Asia to Japan.

The two drugs and the plants yielding them resemble one another very closely, but in spite of a close histological, chemical, and toxicological resemblance they are usually regarded as distinct species.

History.—The North American Indians appear to have been long aware of the therapeutic activity of the American drug, and it was employed by the early European settlers. Its use spread to England about 1862. In Europe the closely allied white hellebore had long been used, and had been official in all the London Pharmacopœias until the American drug replaced it in the Pharmacopœia of 1867.

Collection and Preparation.—The rhizome is dug up in the autumn. It is deprived of its leaves and occasionally also of its roots, and is frequently sliced longitudinally to facilitate drying. The drug requires thorough drying and careful storage.

Characters.—Rhizomes, if entire, from 2 to 7 cm. in length. Externally yellowish-brown to brownish-black. At the crown are the remains of closely arranged leaves, the parenchyma of which has frequently perished, leaving the fibro-vascular bundles. The roots are numerous and almost completely cover the rhizome if they have not been cut off. The removal of the roots is an unnecessary procedure since they are quite as active as the rhizome. Entire roots are from 3 to 8 cm. in length and from 1 to 4 mm. in diameter. They are much shrivelled in the American drug. The American rhizomes are more frequently sliced longitudinally than the European ones, but samples vary greatly in this respect and little reliance can be placed on this feature.

Sections show an outer brownish corky layer, a parenchymatous cortex containing raphides of calcium oxalate, and a well-marked endodermis. The fibro-vascular bundles lie in irregular circles throughout the stele and central pith. Leaf-trace bundles and root bundles are found in the cortex.

Constituents.—In spite of numerous investigations on the constituents of the *V. viride* and *V. album*, their chemical identity remains in doubt, and a further examination of both plants seems desirable. Both contain about 0.5 to 1 per cent. of alkaloids. These include jervine (Wright and Luff, 1878), protoveratrine (Salzberger, 1890), pseudojervine, rubijervine, and possibly cevadine.* These alkaloids vary in toxicity and no one of them appears to exert the same action as the whole drug. Veratrum preparations require a biological method for their assay. Both species contain about 25 per cent. of resin.

Uses.—The veratrums are now seldom prescribed in Britain. White hellebore is used to a limited extent for the destruction of pediculi and moths.

* Cevadine (crystalline veratrine) is an alkaloid found in cevadilla seeds (*Schœnocaulon officinale*). It has been reported in *V. album* and *V. viride* (traces), but its presence requires confirmation. *Schœnocaulon* belongs to the same liliaceous subfamily as *Veratrum*.

COLCHICUM AUTUMNALE

Autumn Crocus, Meadow Saffron ; F. Colchique ; G. Zeitlose

Source.—The genus *Colchicum* consists of some thirty species, one of which, *Colchicum autumnale*, the autumn crocus, is indigenous to Britain. It is found in England, particularly in damp meadows in limestone districts, and in Ireland. *Colchicum* grows also in Central and Southern Europe and in North Africa. In the U.S.A. colchicum culture has been attempted but with a limited amount of success.

History.—Dioscorides was aware of the poisonous nature of a *Colchicum* which may or may not have been the species now used in medicine. The genus derives its name from Colchis on the Black Sea, one of the places where this plant is found. The drug was recommended in Arabian writings for use in gout, but it was little employed either in classical or mediæval times owing to the wholesome fear inspired by its poisonous properties. *Colchicum corm* appeared in the London Pharmacopœias of 1618, 1627, 1632, and 1639. It was then deleted but reappeared in the edition of 1788. The uncertain action of the corm led Dr. W. H. Williams, of Ipswich, to introduce the use of the seeds about 1820, and these were admitted to the Pharmacopœia of 1824.

Characters.—*Colchicum* plants should be dug up at different seasons and carefully examined. The corm consists of an enlarged underground stem bearing foliage leaves, sheathing leaves, and fibrous roots. If the plants are examined in the latter part of the summer it will be found that a new corm is developing in the axil of a scale leaf near the base of the old corm, the new plant occupying an infolding in the side of the parent corm. In September the parent corm bears the remains of recently withered leaves and is very much larger than the daughter corm. For medicinal purposes the corm would have been collected shortly after the withering of the leaves (B.P. "early summer"), and before the enlargement of its axial bud. The corms are surrounded by a dark, membranous coat. The young corm develops fibrous roots at its base, and in August or September from two to six flowers emerge from it, but its foliage leaves do not appear above ground until the following spring.* The flowers are from 10 to 12 cm. long.

* Students are sometimes inclined to think that the development of foliage leaves precedes flowering; the reverse, however, is the case, since the leaves appearing in the spring of 1938 do not belong to the corm which bears flowers in the autumn of that year.

Each has six stamens and a perianth consisting of six lilac or pale-purple segments which fuse into an exceptionally long perianth tube, at the base of which lies the superior ovary. More than half the length of the flower is below ground and the fruit lies protected throughout the winter by the surrounding corm and earth. The fruit is a three-lobed, three-celled, septicidal capsule, which is carried above ground in the spring

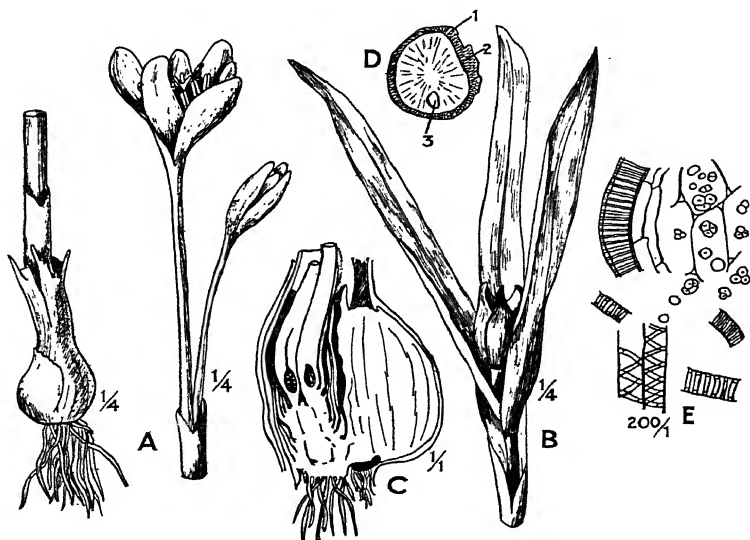


FIG. 70.—*Colchicum autumnale*. A, flowering plant; B, leaves and ripe capsule; C, longitudinal section through the corms in autumn; D, longitudinal section of seed; E, elements of the powdered corm. 1, hilum; 2, strophiole; 3, embryo. (After Thoms, *Handbuch der Pharmazie*.)

by the expanding leaves. The fully grown leaves are radical, linear-lanceolate, and about 12 cm. long. During these changes the daughter corm has been growing at the expense of the parent, which now gradually perishes. Before doing so, however, it may produce in its second spring one or more small corms, by means of which the number of plants may be increased.

COLCHICI CORMUS

Colchicum Corm, B.P.; F. *Bulbe de Colchique*;
G. *Zeitlosenknollen*

Collection and Preparation.—The corms of *Colchicum autumnale* are collected in the early summer, usually in July. There is no doubt that the constituents vary considerably at different periods of the year, and may be modified by the climate and soil in which the plants are grown. The corm may be used in the fresh state or dried. Much dried corm is produced in Holland and in Italy. The corms are cut into thin transverse slices, which are thoroughly dried on paper or perforated trays at a temperature not exceeding 65°. During drying the corms lose about 70 per cent. of their weight. The outer membranes, if not removed before slicing, are separated by winnowing.

Macroscopical Characters.—Fresh corms are roughly conical in shape, from 3 to 5 cm. in height and from 2 to 3 cm. in diameter. One side is rounded and the other, on which the daughter corm develops, somewhat flattened. The corm is covered with a double, membraneous coat, the outer being bright brown in colour and the inner reddish-yellow. The interior is fleshy and starchy, and when cut yields a bitter, starch-containing juice of disagreeable odour.

The dried drug consists of somewhat reniform, transverse slices, and occasional more ovate longitudinal slices, about 2 to 5 mm. thick. The epidermal surface is cinnamon-brown and slightly wrinkled. The interior is white and starchy and, if carefully smoothed, shows scattered fibro-vascular bundles. The drug breaks with a short mealy fracture. The odour is much less marked than in the fresh drug. Taste bitter. On treating the drug with 60 to 70 per cent. sulphuric acid or with hydrochloric acid a yellow colour, due to the presence of colchicine, is produced.

Microscopical Characters.—Microscopical examination shows numerous starch grains contained in parenchyma, some simple but the majority consisting of from 2 to 7 components. Individual grains are from 3 to 30 μ in diameter, and show a triangular or star-shaped hilum. Their shape varies from spherical or ovoid to polygonal. Vessels with a spiral or annular thickening and portions of brownish epidermis with very occasional circular stomata may also be seen.

Constituents.—The chief active constituent is colchicine, an alkaloid which is usually present in the dried corm to the extent of 0.25 to 0.60 per cent. As mentioned above, the corm varies in activity according to the season at which it is collected and probably also according to climate and soil, and it is reported that peasants in certain parts of Austria use the corms collected in autumn as food. Corms collected in April are more bitter than those collected in July.

Colchicine is an amorphous, yellowish-white alkaloid, which darkens on exposure to light and gives a deep yellow colouration with strong mineral acids. It is hydrolysed by boiling with dilute mineral acids or alkalis yielding methyl alcohol and colchiceine (acetyltrimethylcolchicine acid). The latter compound on further treatment with hydrochloric acid yields colchicine acid. Colchicine readily dissolves in water, alcohol, or chloroform, but is only slightly soluble in ether or petroleum spirit. It is a feeble base, yielding an aqueous solution which is neutral to litmus, and it may be extracted from either acid or alkaline solution by means of chloroform. When using chloroform for the assay of colchicum preparations care must be taken to remove all the chloroform before weighing, since the alkaloid forms a crystalline compound of the formula $C_{22}H_{25}NO_6 \cdot 2CHCl_3$. It is interesting to note that colchicine has been found in *Gloriosa superba*, a plant which also belongs to the subfamily Melanthioideæ.

Uses.—Colchicum corm is used to relieve gout, but it may cause gastro-intestinal irritation and must be used with considerable caution.

COLCHICI SEMEN

*Colchicum Seed, B.P. ; F. Semence de Colchique ;
G. Zeitlosensamen*

Collection and Preparation.—Colchicum seeds are the seeds of *Colchicum autumnale* which are collected when ripe, usually about the end of July or the beginning of August, and dried. Supplies are derived mainly from the Continent. It is said that the seeds do not mature in plants cultivated in dry soil.

Macroscopical Characters.—Colchicum seeds are ovoid or globular in shape and from 2 to 3 mm. in diameter. They are extremely hard and have a reddish-brown, minutely-pitted testa. During drying the seeds darken in colour and become covered with a sugary exudation. The seed, as in most Liliaceæ,

develops from an anatropous ovule. From a slight projection at the hilum there extends for about one quarter of the circumference a well-marked strophiole. This is an outgrowth of the testa somewhat resembling the caruncle found in a castor seed. The small embryo lies at the end remote from the hilum embedded in horny endosperm (Fig. 70).

Microscopical Characters.—Microscopical examination shows that the testa consists of somewhat thick-walled, reddish-brown parenchyma; that the endosperm cells have pitted walls and contain fixed oil, and aleurone grains 3 to 15 μ in diameter; and that the strophiole contains starch.

Constituents.—Colchicum seeds usually contain rather more colchicine than the corm, the percentage varying from 0.2 to 0.8 per cent. The British Pharmacopœia specifies not less than 0.3 per cent. of colchicine for the seeds, and not less than 0.25 per cent. of colchicine for the dried corm.

Colchicum seeds also contain a resin (colchicoresin), fixed oil (up to 8 per cent.), reducing sugars (up to 5 per cent.), proteins, starch, and mineral matter. They yield about 3 per cent. of ash.

Uses.—Colchicum seeds are used for the same purposes as the corm.

ALOE

Aloes; F. *Aloès*; G. *Aloë*

About 160 species of *Aloe* are known. Most of them are indigenous to Africa, but some have been introduced into the East and West Indies and Europe. The aloes are typical xerophytes with fleshy, strongly cuticularised leaves, which are usually prickly at the margin. The genus includes herbaceous, shrubby and arborescent forms, the latter sometimes attaining a height of as much as 18 m. The inflorescence consists of spikes of white, yellow or red flowers which may be distinguished from those of the agave, *Agave americana* (Amaryllidaceæ), by their superior ovary.

The following species appear to be those from which the drug is mainly obtained, but the leaves of other species may be used to some extent.

Aloe Perryi Baker, a species found on the Island of Socotra, in Eastern Africa, and in Arabia. A perennial herb with a stem about 15 to 20 cm. high, which bears a dense rosette of pale green or reddish lanceolate leaves with marginal spines. Flowers turning from reddish to yellow.

Aloe vera Linn. (*Aloe vulgaris* Lamarck, *Aloe barbadensis* Mill., *Aloe officinalis* Forskal), a species indigenous to North Africa but cultivated in the West Indies. Stem about 30 to 60 cm. high bearing glaucous green leaves 15 to 30 cm. in length with distinctly arranged spines perpendicular to the margin. Flowers yellow.

Aloe chinensis Baker is considered by Engler to be a variety related to *A. vera*. The leaves are, however, shorter than those of *A. vera* and are spotted on the dorsal surface. The plant was introduced from China into Curaçao by W. Anderson in 1817.

Aloe ferox Miller is a South African species with a forked stem 3 to 6 m. high (Fig. 71). It bears a dense rosette of leaves and whitish flowers. The leaves are about 15 to 16 cm. in length and bear prickles at their margin and on both dorsal and ventral surfaces.

Aloe africana Miller and *Aloe spicata* Baker are tree-like species found in South Africa, where they readily hybridise with *Aloe ferox*.

Transverse sections of an *Aloe* leaf usually show the following zones: (a) a

strongly cuticularised epidermis with numerous stomata on both surfaces; (b) a region of parenchyma containing chlorophyll, starch, and occasional bundles of needles of calcium oxalate; (c) a central region, which frequently occupies about three-fifths of the diameter of the leaf, consisting of large, mucilage-containing parenchymatous cells; (d) a double row of vascular bundles which lie at the junction of the two previous zones and have a well-marked pericycle and endodermis. The aloetic juice from which the drug is prepared is contained in the large, pericyclic cells and sometimes in the adjacent parenchyma.

The British Pharmacopœia defines aloes as "the liquid,

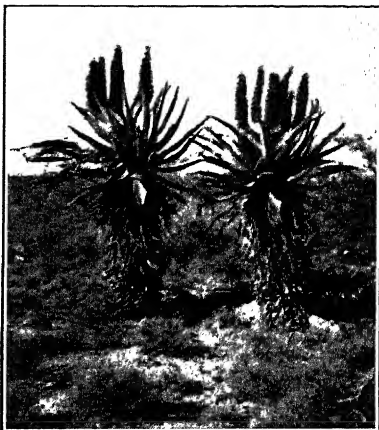


FIG. 71.—*Aloe ferox* Mill growing in Cape Province (photo by courtesy of Dr. I. B. Pole Evans).

evaporated to dryness, which drains from the leaves cut from various species of *Aloe*; it is known in commerce as Cape, Curaçao, Socotrine, or Zanzibar aloes." The nature of the product depends not only on the plant used but on the way in which the juice is evaporated. Speaking generally, slow spontaneous evaporation gives an opaque aloes, often called hepatic* or livery aloes, while more rapid evaporation at a higher temperature gives a glassy or lucid aloes.

The chief commercial varieties of aloes, namely, Socotrine, Zanzibar, Cape and Curaçao, will now be described.

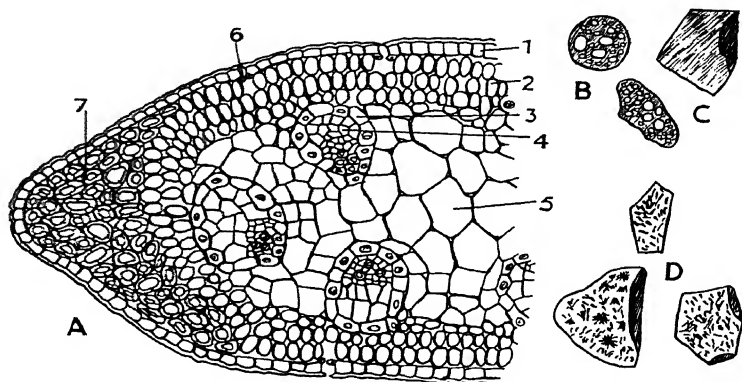


FIG. 72.—A, transverse section of an aloes leaf; B, Cape aloes in water; C, the same in glycerin; D, hepatic aloes in glycerin. 1, epidermis; 2, palisade cells; 3, endodermis; 4, pericyclic cells in which the aloetic juice is contained; 5, mucilage-containing cells; 6, stoma; 7, sclerenchyma. (A after Hérail, B-D after Thoms.)

Socotrine Aloes; F. *Aloès Soccotrin*; G. *Sokotraaloë*

Source.—Socotrine aloes is derived from *Aloe Perryi* Baker and probably other species of *Aloe*. The drug is prepared in East Africa, the Island of Socotra, and Arabia and is conveyed by Arab traders to Bombay.

* *Pharmacographia*, p. 684: "The *Hepatic Aloes* of the old writers was doubtless this rather opaque form of Socotrine aloes; but the term has come to be used somewhat vaguely for any sort of liver-coloured aloes, but appears to us unworthy to be retained. Much of the opaque, so-called *Hepatic Aloes* does not, however, owe its opacity to crystals, but to a feculent matter, the nature of which is doubtful."

History.—According to legend, Socotrine aloes was known to the Greeks as early as the fourth century B.C., and Greek colonists were sent to the Island by Alexander the Great solely to preserve and cultivate the aloe plant. The drug was apparently known in England in the tenth century, and from the seventeenth-century records of the East India Company it would appear that they frequently purchased the whole stock of aloes of the “King of Socotra.”

Collection and Preparation.—Socotrine aloes is obtained by allowing the juice from the cut aloe leaves to drain into a goat's or sheep's skin, where it is allowed to evaporate spontaneously. After about a month the viscous product is known as *Jâyeḡ Gesheeshah*, and when it has hardened still further *Jâyeḡ Kasahul*. The still damp product is brought by Arab traders, *via* the Red Sea ports or Zanzibar, to Bombay. The drug arrives from Bombay in barrels, kegs, tins, or skins. It is usually somewhat pasty and is dried in a warm room on wooden trays until the moisture content has been sufficiently reduced. The official drug loses, when dried at 100°, not more than 10 per cent. of its weight.

Characters.—Socotrine aloes occurs in masses of varying size and shape. The colour is usually yellowish-brown to blackish-brown. The drug is opaque and breaks with an uneven, somewhat porous fracture.

Socotrine aloes has a characteristic odour which some writers have described as “almost fragrant,” while others describe it as “unpleasant.” * Aloes has a bitter, nauseous taste.

Powdered Socotrine aloes, if examined under the microscope (Fig. 72) in a glycerin, lacto-phenol, or olive oil mount, shows numerous, minute crystals of aloin embedded in transparent yellowish-brown masses of resin. When examined in polarised light with crossed nicols hepatic aloes (*e.g.* Socotrine) show shining, needle-like crystals of aloin embedded in an amorphous resinous mass, whilst vitreous aloes (*e.g.* Cape) contain no crystals and remain dark.

Zanzibar Aloes ; F. Aloès de Zanzibar ; G. Zanzibaraloe

Zanzibar aloes is often regarded as a variety of Socotrine, but the differences between the two varieties may be due to

* “The odour of aloes is a character which is much depended on by dealers for distinguishing the different varieties, but it can only be appreciated by experience, and certainly cannot be described” (*Pharmacographia*)

the use of different species of *Aloe* as well as to differences in the method of preparation. The drug is packed in leaves (Fig. 73A) or skins (the so-called "monkey skins") which are probably derived from carnivorous animals or ungulates such as the gazelle. The skins and their contents, each weighing about 30 to 40 lb., are packed in cases and reach London from the East Coast of Africa *via* Bombay.

Zanzibar aloes, when first imported, is usually somewhat firmer than the Socotrine. It has a liver-brown colour, is opaque and breaks with a smooth waxy fracture. The odour



FIG. 73A.—Piece of Zanzibar aloes packed in leaf.



FIG. 73B.—"Monkey-skin" aloes, P.L.A. (Chemist and Druggist).

is generally considered to be fairly pleasant, but the taste is bitter and disagreeable. Zanzibar aloes sometimes closely resembles the Curaçao variety, although the odour is different and, if pieces of skin and leaf are absent, chemical tests may be necessary to establish its identity. For powder, see p. 97.

Cape Aloes ; F. *Aloès du Cap* ; G. *Kapaloë*

Source.—Cape aloes is obtained from *Aloe ferox*, Fig. 71 and hybrids of this species with *Aloe africana* and *Aloe spicata*.

History.—Cape aloes has been exported since about 1780. Although now official, this variety was not included in the B.P. 1914, but was much used in veterinary practice and on the Continent.

Collection and Preparation.*—"A hole is dug in the ground about 20 ins. in diameter and 6 ins. deep. This is lined with canvas or goat skin. The leaves are cut from nearby *Aloe* trees and about 200 to 250 of these are arranged with their cut ends about the hole in such a way that the juice, as it exudes, falls straight into the canvas. That is, the



FIG. 74.—Collection of juice from leaves of *Aloe ferox* (photo by courtesy of Dr. I. B. Pole Evans).

leaves overlap each other at the cut end and gradually taper towards the top in the shape of a pyramid. In favourable weather the leaves are exhausted in about six hours.

* Being unaware of any more recent account of the preparation of Cape aloes than that quoted by Hanbury in the *Pharmacographia* from a letter dated 1871, one of my former students, Mr. J. H. Farrer, M.P.S., made inquiries which show that the earlier account is still substantially correct. For the information quoted above and the photographs reproduced in Figs. 71 and 74 I am indebted to the Principal Botanist and to the Chief of the Division of Plant Industry of the Union of South Africa. As far as can be ascertained the drug has not yet been marketed in England in the form of the briquettes mentioned above. Any information on this point would be welcomed.

PHARMACOGNOSY

" The juice is then transferred from the canvas to a drum or paraffin tin in which it is boiled for four to five hours on a medium fire, stirring continuously. To prove the 'Aloes,' a little is taken out with the stirrer from time to time, and when it is brittle on cooling the aloes is of the proper grade. I might add that even when of the proper grade, and packed in tins or cases, sun and moisture tend to make it soft again. If poured into wooden moulds, which on cooling would give oblong briquettes weighing $\frac{1}{2}$ lb. and these briquettes are immediately wrapped in butter paper or tin foils and packed into a sealed tin or lead-lined container, then there is the least chance of damage or spoilage in transit. . . .

" . . . For England and the Continent of Europe it is packed in yellow-wood cases weighing about 250 lb. gross each. The practice in the Mossel Bay district is for owners to let out the tapping to poor whites or coloured labourers for a royalty of 25 per cent. of the proceeds. Although plants may be tapped at any season of the year, yet in times of drought or in windy weather the juice will not flow. The optimum time to tap is a few days after rain."

Characters.—Cape aloes is packed in cases of 4, 2, and 1 cwt. and in tins containing 56 lb. Two of the latter are often packed in a case. The drug occurs in dark-brown or greenish-brown, glassy masses. Thin fragments have a deep olive colour and are semi-transparent. The powder is greenish-yellow and when pieces of the drug have rubbed against one another patches of powder are found on the surface. The drug has a very characteristic, sour odour (the so-called rhubarb or apple-tart odour), which is particularly noticeable if one breathes on the drug before smelling. Taste, nauseous and bitter. The powder when examined under the microscope in lacto-phenol is seen to be amorphous (see Fig. 72).

Curaçao or West Indian Aloes ; F. *Aloès de Curaçao* ; G. *Curaçaoaloe*

e.—Curaçao aloes is obtained from *Aloe chinensis* Baker, *Aloe vera* Linn., and probably other species of *Aloe*.

History.—The drug was produced in Barbadoes, probably from *Aloe vera*, as early as 1650, and it appeared in European commerce about 1693. For many years the plants were systematically cultivated in Barbadoes and in 1843 no fewer than 4227 gourds, each containing 20 to 60 lb., were exported. Cultivation in this island has now almost or completely lapsed, the export for the years 1893–1902 amounting to only £35. The drug, which is still often called Barbadoes aloes, comes from the Dutch Islands, Curaçao, Aruba, and Bonaire, which lie some 50 miles from the coast of Venezuela.

Collection and Preparation.—The method used in both Barbadoes and Curaçao is described by Fluckiger and Hanbury * as follows :—

“ The cutting takes place in March and April, and is performed in the heat of the day. The leaves are cut off close to the plant, and placed *very quickly*, the cut end downwards, in a V-shaped wooden trough, about 4 feet long and 12 to 18 inches deep. This is set on a sharp incline, so that the juice which trickles from the leaves very rapidly flows down its sides, and finally escapes by a hole at its lower end into a vessel placed beneath. No pressure of any sort is applied to the leaves. It takes about a quarter of an hour to cut leaves enough to fill a trough. The troughs are so distributed as to be easily accessible to the cutters. Their number is generally five ; and by the time the fifth is filled, the cutters return to the first and throw out the leaves, which they regard as exhausted. The leaves are neither infused nor boiled, nor is any use afterwards made of them except for manure.

“ When the vessels receiving the juice become filled, the latter is removed to a cask and reserved for evaporation. This may be done at once, or it may be delayed for weeks or even months, the juice, it is said, not fermenting or spoiling. The evaporation is generally conducted in a copper vessel ; at the bottom of this is a large ladle, into which the impurities sink, and are from time to time removed as the boiling goes on. As soon as the inspissation has reached the proper point, which is determined solely by the experienced eye of the workman, the thickened juice is poured into large gourds or into boxes, and allowed to harden.”

Characters.—Curaçao aloes in gourds is only seen in museums, the drug being now imported in spirit cases, each containing about 130 lb. The drug is usually opaque, but a semi-transparent form, known as “ Capey Barbadoes,” is also imported. The latter becomes more opaque on keeping, probably owing to slow crystallisation of aloin. Typical Curaçao aloes varies in colour from yellowish-brown to chocolate-brown, but poorer qualities, which have been overheated, may be almost black. The drug breaks with a waxy fracture, and although the experienced may distinguish it from Zanzibar by its appearance and odour, others may prefer to rely on chemical tests, especially if the amount of drug supplied for identification is small.

Chemical Tests for Aloes

(a) **General Reactions.**—For the following tests boil 1 G. of drug with 100 ml. of water ; add a little kieselguhr and

* *Pharmacographia*, p. 682. The production of Barbadoes aloes was also described by W. G. Freeman in a lantern lecture, which is reported in the *P.J.*, 1908, Dec. 12, 768.

filter. Use separate portions of the filtrate for the following tests :—

1. *Schönteten's Reaction*.—To 5 ml. of solution of aloes add 0.2 G. of borax and heat until dissolved. Pour a few drops of the liquid into a test-tube nearly full of water. A green fluorescence is produced the origin of which is discussed below under Constituents.

2. *Bromine Test*.—To 2 ml. of solution of aloes add 2 ml. of freshly prepared solution of bromine. A pale yellow precipitate of tetrabromaloin is produced. This test is not specific for aloes (see also p. 676).

(b) *Special Reactions*.—1. *Nitric Acid Test*.—To 5 ml. of solution of aloes add 2 ml. of nitric acid. Cape aloes gives a brownish colour rapidly changing to green; Curaçao a deep brownish-red; Socotrine a pale brownish-yellow; and Zanzibar a yellowish-brown colour. Nitric acid may be applied direct to the powdered drugs with similar results.

2. *Nitrous Acid Test*.—This test, which appears to be specific for drugs containing isobarbaloin, is described on p. 677.

3. *Klunge's Isobarbaloin Test*.—To 20 ml. of an aqueous 1 in 200 solution of aloes add a drop of saturated copper sulphate solution, followed by 1 G. of sodium chloride and 10 ml. of alcohol 90 per cent. With Curaçao aloes a wine-red colour is developed, which persists for at least twelve hours. With Cape aloes a lesser colouration may develop, which, however, rapidly fades to yellow. Zanzibar and Socotrine aloes give no colour. The appearance of the red colour may be hastened by warming.

4. *Bornträger's Test*.—Shake 10 ml. of aloes solution with 10 ml. of benzene for 1 minute. Separate the benzene solution and shake it with dilute solution of ammonia. The alkaline solution is coloured pink or cherry-red when Curaçao, Zanzibar, or Socotrine aloes are used. Cape frequently only gives a brown colour, and Natal (no longer a commercial article) no reaction. The test is said to be due to the presence of aloemodin.

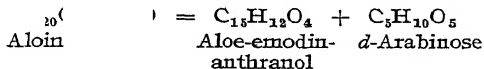
Constituents

Aloes contains glycosides, known as the aloins, and resins. The glycosides of different varieties were formerly known as barbaloin, socaloin, and capaloin, but the name barbaloin is now applied to a pale-yellow, crystalline glycoside found in

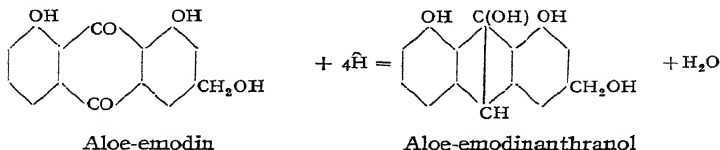
all varieties (Léger, 1907). The name aloin is applied to a mixture of the crystalline glycosides the preparation of which is described by Barrowcliff and Carr * as follows :—

“ For the preparation of aloin powdered Barbadoes aloes is dissolved in 9 to 10 times its weight of boiling water. The solution is acidified with sulphuric acid, allowed to cool and filtered from resinous matter. The bright filtrate is neutralised and evaporated down *in vacuo* until it has a volume of about one gallon for each five pounds of aloes taken. It is then allowed to cool, a few crystals of aloin are added, and it is allowed to stand. When crystallisation is completed, the crystals which have separated are filtered off, and washed with a small quantity of diluted alcohol. They are recrystallised from dilute ethyl alcohol or from methyl alcohol. The yield is, according to the quality, 10 to 20 per cent. of the weight of aloes taken.”

Aloin was first isolated by T. and H. Smith of Edinburgh in 1851, from Barbadoes aloes. Tilden (1875) gave it the formula $C_{16}H_{19}O_7$, but the investigations of Léger (1903) caused him to suggest $C_{21}H_{20}O_9$. Jowett and Potter (1905) supported Tilden's formula, but Léger after further work (1907) adhered to the formula $C_{21}H_{20}O_9$. According to Léger, barbaloin is decomposed on prolonged keeping in alcoholic solution or on treatment with sodium peroxide into aloemodin and *d*-arabinose. More recently Rosenthaler † has shown that aloin gives *d*-arabinose and an anthranol, aloemodinanthranol on hydrolysis and that its formula is $C_{20}H_{20}O_8$. The hydrolysis may be represented :



The formation of an anthranol from aloemodin may be represented :



A solution of aloemodinanthranol in concentrated borax solution or caustic alkali shows a greenish fluorescence. With

* Barrowcliff and Carr, *Organic Medicinal Chemicals*, p. 199.

† Rosenthaler, *Pharm. Act. Helv.*, 1932, 7, 19, and *Arch. Pharm. Berl.*, 1932, 270, 214, through *Y. B. Pharm.*, 1932, 106 and 307.

selenious acid and sulphuric acid it becomes brown, showing greenish streaks, and then turns black. This behaviour is characteristic of anthranols.*

Léger (1908) showed that barbaloin on heating to 160°—165° for three hours is partly converted into β -barbaloin, an amorphous substance giving a tetrabromide in the form of prismatic needles. This glycoside is said to be absent from the Curaçao variety but to be present in the Cape to the extent of about 8 per cent.

Isobarbaloin, a crystalline isomer of barbaloin, appears to be present in quantity only in the Curaçao variety. Most varieties of aloes contain sufficient free anthraquinones to give Bornträger's test. There is no accurate method for the estimation of aloins, but from 10 to 20 per cent. of crystalline aloins can be extracted on the commercial scale from Curaçao aloes. The other commercial varieties generally yield less.

Aloes contain a considerable amount of resin which is said to have a purgative action and in the case of the Cape at least is said to contribute more to the therapeutic action than the aloins. On hydrolysis the resin of Curaçao aloes yields a resin-alcohol (barbaloresinotannol) and cinnamic acid. The resin of Cape aloes similarly yields capaloresinotannol and *p*-hydroxycinnamic (*p*-coumaric) acid. Little is known of these resinotannols and it has been suggested that they are mixtures of decomposition products formed during the hydrolysis of the original resins. Kiefer has distinguished three resins in Cape aloes differing in their solubility in alkaline solutions. The resin of Socotrine and Zanzibar aloes, as far as is known, resembles the Cape.

Uses.—Aloes is widely employed as a purgative. It is seldom prescribed alone as its activity is increased when it is administered with small quantities of soap or alkaline salts, while carminatives moderate its tendency to cause griping.

* The borax fluorescence test was formerly thought to be due to barbaloin, but araroba and chrysarobin, which contain anthranols, give an equally good fluorescence with borax and also respond to the test with selenious acid and sulphuric acid. Natal aloes did not give the borax test and would therefore appear to contain no anthranol. Rhubarb, although it is said to contain anthranol glucosides at certain periods of the year, does not seem to contain free anthranols.

SCILLÆ BULBUS

Scilla, B.P.; *Squill*; F. *Scille*; G. *Meerzwiebel*

Source.—Squill consists of the dried sliced bulbs of *Urginea Scilla* Steinh. (*Scilla maritima* Linn.) from which the membranous outer scales have been removed. The plant grows on sandy soil on the Mediterranean coasts of Spain, France, Italy, Sicily, Malta, Greece, Algiers, and Morocco. English supplies are derived largely from Malta and Italy (Leghorn).

Collection and Preparation.—The bulbs are collected in August, a month in which the plant is without aerial leaves. After removing the dry, outer scales the bulbs are cut transversely into thin slices. These are dried in the sun or by stove heat, when they lose about 80 per cent. of their weight. The dried slices are packed in bags (containing about 1 cwt.) or in barrels.

History.—Squill was well known to the early Greek physicians and to the Egyptians. A vinegar of squills was known to Dioscorides and an oxymel of squills to the Arabian physicians.

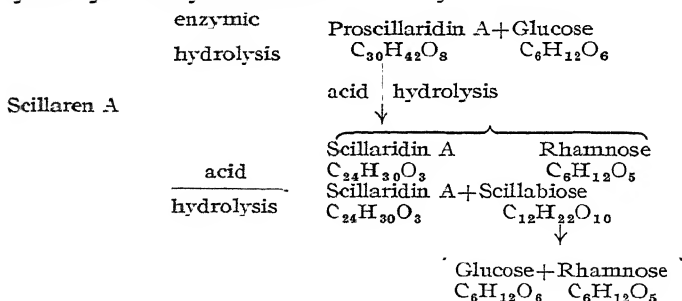
Macroscopical Characters.—Squill bulbs are pear-shaped and vary in size from that of a man's fist to that of a football. A common size measures 18 to 20 cm. in height, has a diameter of about 15 cm., and weighs about 3,000 G. Two varieties of squill are recognised: (1) *White squill* (Italian or female squill), a variety with whitish or yellowish outer scales cultivated in Malta, Sicily, and Italy; and (2) *red squill* (Spanish squill or male squill), a variety with reddish scales cultivated in Algiers. White squill is generally used in England and red squill in France, but apart from the colour of the enveloping scales there appears to be little difference between the two varieties.

The dried drug occurs in yellowish-white, translucent strips about 0.5 to 5 cm. in length and tapering at both ends. The drug is brittle when perfectly dry but it readily absorbs moisture and becomes tough and flexible. The hygroscopic nature is particularly noticeable in the powdered drug which, if carelessly stored, tends to cake into solid masses and develop mould. It should be stored in an atmosphere free from moisture. A glass-stoppered bottle, the stopper of which is hollow and contains a dehydrating agent separated from the

squill by a piece of chamois leather, is suitable. Odour, slight ; taste, bitter and acid.

Microscopical Characters.—Squill is easily identified microscopically by the abundant, mucilage-containing parenchyma and by the bundles of acicular crystals of calcium oxalate, up to 900μ in length, which are often imbedded in the mucilage. The latter can be stained with corallin soda. A few rounded starch grains, about 10μ in diameter, and an occasional stoma may also be found. See also p. 100.

Constituents.—Squill contains cardiac glycosides which have been investigated by Merck (1879), Schmiedeberg (1881), Jammerstedt (1881), Waliszewski (1893), Kopaczewski (1914), and Stoll (since 1923). The substances isolated by Merck (scillitoxin, scillipicrin and scillin) and by Kopaczewski (scillin) must now be regarded as mixtures rather than pure chemical compounds. In 1923 Stoll* isolated a crystalline glycoside, scillaren A, and an amorphous scillaren B. Scillaren A, the most important constituent of squill, is readily hydrolysed by an enzyme scillarenase or by acids as follows :—



To isolate the glycosides it is thus necessary to prevent hydrolysis. The squill glycosides are chemically related to those of *strophanthus* (p. 558) and *digitalis* (p. 596). The drug also contains sinistrin, a carbohydrate resembling inulin ; mucilage and calcium oxalate. It yields about 2 to 5 per cent. of ash.

Allied Drug.—Indian squill or *urginea*, the dried sliced bulb of *Urginea indica*, was official in the 1914 Pharmacopœia. It occurs in curved pieces of a darker colour than those of European squill. These are frequently attached to a portion of the axis, a part of the bulb which is usually rejected in the

* For a full account of the squill glycosides, see Stoll, *The Cardiac* (1937), 23-50.

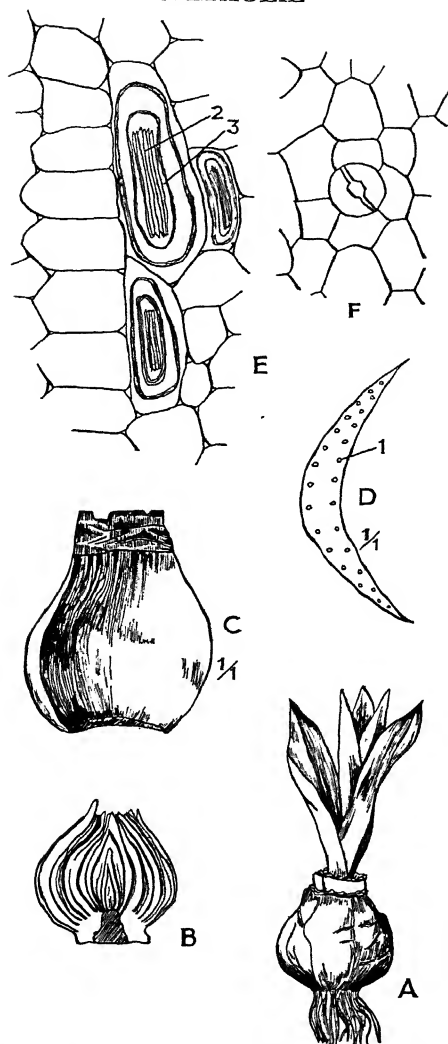


FIG. 75.—*Urginea Scilla*. A, whole bulb; B, longitudinal section of same; C, a single scale of same; D, transverse section of scale; E, longitudinal section of scale; F, epidermis of same. 1, vascular bundle; 2, raphide of calcium oxalate; 3, sheath of mucilage. (All after Tschirch and Meyer.)

case of *Urginea Scilla* on account of its very mucilaginous nature.

Uses.—Squill has a digitalis-like action on the heart and in small doses is used as an expectorant. In larger doses it is emetic. Squill is also used as a rat poison.

CONVALLARIÆ FLORES

*Lily of the Valley Flowers ; F. Fleurs de Muguet ;
G. Maiblumen*

Source.—The drug consists of the dried inflorescences of the lily of the valley, *Convallaria majalis*, a small perennial herb common in many parts of England, Europe, Asia, and the South-Eastern U.S.A. During the drying the white fragrant flowers turn brownish-yellow and almost completely lose their odour.

Characters.—The inflorescence is a slender scape bearing from 3 to 8 bell-shaped flowers. These are of typical liliaceous type each having a perianth with six recurved teeth, six stamens, and a superior three-celled ovary. The drug has little odour and a bitter taste.

Constituents.—According to Langlebert (1885) the lily of the valley plant contains two glycosides, convallamarin (amorphous, soluble in water) and convallarin (insoluble in water). Under the influence of dilute acids convallamarin is said to yield glucose and convallamaretin, whilst convallarin yields glucose and convallaretin. Cohn (1913) describes convallamarin as a white crystalline substance of the formula $C_{23}H_{44}O_{12}$, yielding on hydrolysis glucose and convallamaretin. Lindner (1916) was unable to obtain convallarin in crystalline form; it is very hygroscopic, but when dried over calcium chloride it gave the formula $C_{25}H_{40}O_{10}$. On hydrolysis it gave a hexose (? glucose) and convallaretin $C_{19}H_{28}O_4$.

Biological tests made by Zondek (1922) show the relative potency of the herb, flowers, and roots to be in the ratio of 6, 10, and 85.

Karrer (1929) isolated convallatoxin, a physiologically active glycoside. It occurs in needle-like crystals, m.p. 212° , which are only slightly soluble in water. Pharmacological assay on the frog's heart show it to be more active even than ouabin (g-strophanthin), previously considered to be the most potent glycoside of this class.

Uses.—Preparations of lily of the valley flowers and of the rhizome are used to a limited extent for their cardiac action. They appear, however, to be inferior to digitalis preparations.

SARSAPARILLÆ RADIX

Sarzae Radix ; *Sarsaparilla Root* ; F. *Racine de Salsepareille* ; G. *Sarsaparillwurzel*

Source.—Sarsaparilla consists of the dried roots and sometimes also of the rhizomes of species of *Smilax*. The deter-

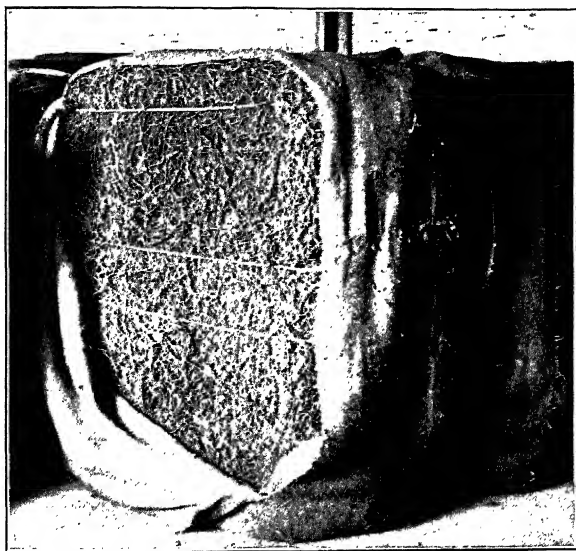


FIG. 76.—Bale of Native Red Jamaica Sarsaparilla in the Cutler Street Warehouse (*Chemist and Druggist*).

mination of the exact geographical and botanical sources of the numerous varieties which have from time to time been imported has been a matter of some difficulty. This is explained to some extent by the large number of species in the genus *Smilax* (about 200) and that they are dioecious and frequently inhabit swampy tropical forests. The more important species appear to be :

1. *Smilax ornata* Hooker filius (Central America and South Mexico).

2. *Smilax saluberrima* Gilg (*S. utilis* Hemsley) (Honduras, San Salvador, and Guatemala).

3. *Smilax medica* Schlechtendal et Chamisso (Mexico).

4. *Smilax papyracea* Duhamel (French Guiana, Brazil; also cultivated in Jamaica).

5. *Smilax syphilitica* Humboldt and Bonpland (Tropical South America).

6. *Smilax officinalis* Humboldt, Bonpland and Kunth (Tropical South America, e.g. Colombia).

Collection.—The plants produce numerous roots, 3 m. or so in length, which are attached to a short rhizome. After scraping away the earth the roots are cut, sufficient, however, remaining in the ground for the plant to resume its growth. Sometimes the rhizome as well as the roots are collected. After drying in the sun the drug is made into bundles and the latter into bales.

History.—Sarsaparilla was introduced into Europe by the Spaniards about the middle of the sixteenth century. Many different kinds have been imported from time to time, some of which are now obsolete. The so-called Jamaica sarsaparilla was official in the B.P. 1898 and is included in the U.S.P. XI, together with Honduras and Mexican sarsaparillas.

The chief commercial varieties of sarsaparilla are as follows:—

1. **Costa Rica, Red "Jamaica" or Central America Sarsaparilla** is obtained from *Smilax ornata* Hooker filius, which is grown in Central America, especially Costa Rica. The drug is often known as Jamaica sarsaparilla owing to the fact that it formerly entered into commerce *via* Jamaica.

Costa Rica sarsaparilla arrives in large bales bound with iron wire, each bale consisting of a number of bundles about 45 cm. in length and 13 cm. in diameter. The drug consists entirely of long flexible roots and rootlets, pieces of rhizome ("chump") being absent. The roots are from 2 to 5 mm. in diameter and bear numerous fibrous rootlets ("beard") about 0.5 to 1.0 mm. in diameter. Owing to shrinkage of the cortex, the roots bear about 10 to 15 more or less prominent longitudinal ridges. The drug is usually reddish-brown in colour but the colour is somewhat variable. It has no marked odour but a bitter and acrid taste. The degree of acidity is

said to be a good indication of the freshness and activity of the drug.

A transverse section of the root shows a narrow, reddish-brown cortex surrounding a yellowish wood and starchy pith. For an account of the microscopic characters of the sarsaparillas the reader is referred to Thoms' *Handbuch der Pharmazie** and the U.S.P. XI.

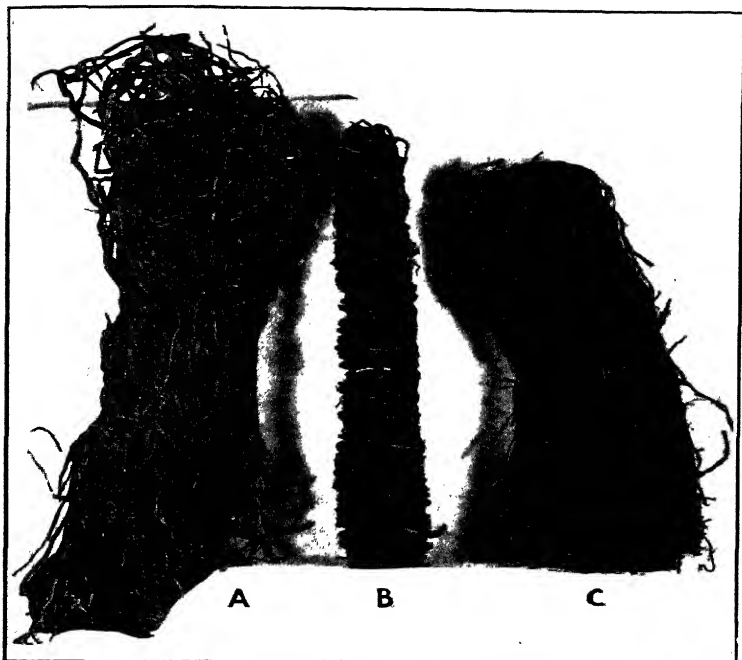


FIG. 77.—Sarsaparillas. A, Vera Cruz; B, Honduras; C, Jamaica. (One-sixth natural size) (Sutcliffe).

2. Honduras or Brown Sarsaparilla is obtained from *Smilax saluberrima* Gilg, which is grown in British Honduras, San Salvador, and Guatemala.

The drug is imported in bales each consisting of a large

* Thoms, *Handbuch der Pharmazie*, Band V, pp. 574-579. Excellent figures are given of the hypodermal and endodermal regions of nine commercial varieties of sarsaparilla, these regions being the most characteristic for distinguishing the different species.

number of bundles. The bales, which are known as serons, have coverings of raw hide at either end which are joined to one another down the sides of the bale by raw-hide thongs. The individual bundles of drug vary from 50 to 75 cm. in length and from 5 to 7 cm. in diameter. They consist entirely of roots and rootlets, the latter being less numerous than in the Costa Rica drug. The roots are usually somewhat thicker and less shrunken than the Costa Rica and brownish in colour. Their diameter varies from about 4 to 6 mm.

3. **Vera Cruz, Mexican, or Grey Sarsaparilla** is obtained from *Smilax medica* Schlechtendal et Chamisso and is collected in Eastern Mexico. The drug is not necessarily made into bales and may occur with or without rhizome. It is usually found in loose bundles about 65 cm. in length consisting of roots and a few pieces of rhizome. The roots are from 3 to 7 mm. in diameter, and the pieces of rhizome about 2 to 4 cm. in diameter. Both are greyish in colour externally.

4. **Native or Cultivated Jamaica Sarsaparilla** is grown in Jamaica. Some doubt exists as to the plant or plants from which it is derived, different writers attributing it to *Smilax officinalis* Humboldt, Bonpland et Kunth, *Smilax papyracea* Duhamel, and *Smilax saluberrima* Gilg (*S. utilis* Hemsley).

The drug arrives in loosely packed bales consisting of roots and rootlets. Different samples vary considerably in colour, the latter varying from reddish-brown or orange to greyish-brown. They are described in the drug market by such terms as "Native Red Jamaica," "Ordinary Native Jamaica," "Native Jamaica Mixed Colours," and "Pale Native Jamaica." The reddish colours are usually preferred and fetch the highest prices.

5. **Guayaquil or Ecuador Sarsaparilla** is grown in valleys on the western side of the Andes and is thought to be derived from a variety of *Smilax papyracea*. The drug usually occurs in bundles about 50 cm. long and 15 cm. wide, which are packed in rectangular bales. Some samples consist of roots only but others contain also rhizomes and stems. The latter are round and prickly. The roots are mahogany-brown in colour and rather coarse-looking. The bark is thick and rather less furrowed than that of the Costa Rica drug.

6. **Lima or "Lima-Jamaica" Sarsaparilla** is imported from Peru via Panama. It occurs in bales similar to those of the Costa Rica drug. These consist of bundles of roots and rootlets which can only be distinguished with certainty from

the Costa Rica by microscopical examination. The bundles are frequently about 60 cm. long and about 7 cm. in diameter, *i.e.* somewhat longer and narrower than the Costa Rica.

Allied Drugs.—The varieties of sarsaparilla described above are those usually met with in English commerce, but many other varieties, *e.g.* the Para, were formerly imported and may still be used either on the Continent or in South America. A European sarsaparilla derived from *Smilax aspera* and other species is used in Southern Europe. It may be distinguished from the American species by the large amount of tannin which it contains.

China root, at one time a highly valued drug, consists of the large tuberous roots of an Eastern Asiatic species of *Smilax*. It is no longer used in England but is still official in some Continental pharmacopœias.

Indian sarsaparilla or hemidesmus, which was official in the B.P. 1898, was formerly thought to be derived from a species of *Smilax*. It is actually derived from *Hemidesmus indicus* (Asclepiadaceæ), but is now almost obsolete.

Constituents.—The main constituents of the sarsaparillas are saponins. Many of the chemical researches on sarsaparilla have been made on material of doubtful origin and it is said that much of the commercial drug is almost inert owing to age.

A sample of Jamaica sarsaparilla examined by Power and Salway* contained a crystalline glycoside, sarsaponin, $C_{44}H_{76}O_{20.7}H_2O$, which yielded on hydrolysis sarsapogenin, $C_{26}H_{42}O_3$, and glucose. The drug also contained the sterols sitosterol, $C_{27}H_{46}O$, and stigmasterol, $C_{30}H_{50}O$; sitosterol *d*-glucoside; a new crystalline dicarboxylic acid, sarsapic acid, $C_6H_4O_6$; glucose, fatty acids, and about 1.25 per cent. of resinous matter.

The saponin content of samples of sarsaparilla may be compared by testing their power of hæmolyzing blood. According to Hering (1930), Vera Cruz sarsaparilla is rather more active in this respect than the Jamaican, while Honduras is less active than either of the preceding varieties.

Uses.—Sarsaparilla formerly enjoyed a high reputation in the treatment of syphilis, rheumatism, and certain skin diseases. Although its use in medicine has been declining steadily for many years, large quantities are employed in the manufacture of non-alcoholic drinks.

* Power and Salway, *Proc. Chem. Soc.*, 1913, 29, 372; abstracted *Y. B. Pharm.*, 1914, 150.

Family **IRIDACEÆ**

The Iridaceæ consists of 57 genera and 800 species, widely distributed. The members are mostly perennial herbs with a corm (*e.g. Crocus*) or rhizome (*e.g. Iris*). The flowers are hermaphrodite, P_3+3 , A_3+O , $G(\bar{3})$; regular (*e.g. Crocus*) or medianly zygomorphic (*e.g. Iris*). The style is branched and often petaloid. The fruit is a loculicidal capsule with numerous seeds.

CROCUS

Croci Stigmata ; Saffron ; F. and G. Saffran

Source.—Saffron consists of the dried stigmas and tops of the styles of *Crocus sativus*. The colour of the flowers varies and Holmes has distinguished five varieties in addition to the violet-flowered *Crocus sativus* type. The drug is prepared in Spain (New Castile, Aragon, and Murcia), France (S. and S.W. of Paris in the provinces of Loiret, Eure-et-Loire, and Seine-et-Marne), Macedonia, Persia, and in the U.S.A. (Pennsylvania). British supplies are obtained mainly from Spain.

History.—Saffron was prized by the ancients and was cultivated in Greece, Asia Minor, and Persia. Cultivation of the plant in Spain appears to date from the tenth century and in England from the fourteenth century. In 1728 quite large quantities of English saffron were being grown, particularly in the area between Saffron Walden and Cambridge.

Cultivation, Collection, and Preparation.—Saffron corms are planted in July or August in soil carefully prepared during the previous autumn. Furrows are made about 20 cm. wide and 18 cm. deep, the corms being placed in these at about 1 or 2 cm. from one another. The first flowering takes place in September or October of the following year, after which each corm replaces itself by one or more daughter corms. The new corms are about 2 cm. higher in the ground than those of the preceding year and after a number of years the corms lie close to the surface. After three harvests of flowers, the corms, which have at least doubled in number, are dug up in May or June. The best of these are reserved for planting in fresh ground in July or August.

In France the plant is liable to attack by a fungus, *Rhizoctonia violacea* Tul., which causes rotting of the corm.

It seems possible that this disease led to the abandonment of saffron cultivation in England.*

Saffron culture requires abundant labour. The flowers are collected in the early morning, placed in baskets or hampers and conveyed to the picking house. The picker takes each flower in turn in the left hand and breaks the style just below the stigmas with the nail of the right thumb. The detached stigmas are dried by artificial heat, usually charcoal stoves, over which they are placed in hair sieves. Drying is completed in about 30 to 45 minutes, after which the drug is cooled and stored in a dry place. About 90,000 to 100,000 flowers give 5,000 grammes of fresh stigmas or about 1,000 G. of the dried drug.

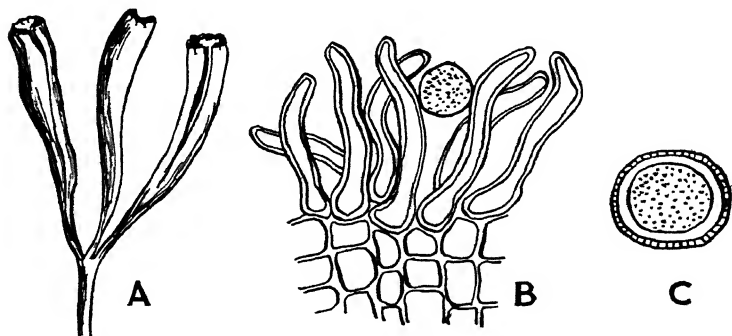


FIG. 78.—Saffron. A, stigmas and top of style; B, stigmatic papillæ; C, pollen grain. (After Planchon.)

Characters.—Saffron, or hay-saffron as it is often called, occurs in loose masses consisting of reddish-brown stigmas among which yellowish pieces, the tops of the styles, can usually be seen. It has a sweetish aromatic odour and a bitter taste. When chewed the saliva is coloured orange-yellow.

If the soaked drug is examined under a lens or microscope, the stigmas will be found either separate or united in threes to the apex of the yellowish styles. A complete style is

* "Notes on the History and Cultivation of Saffron in England," by J. Clarke, *P.J.*, 1887, 1032. "The saffron farmers were called by way of distinction from other farmers 'crocurs' and from the uncertainty of the crop from disease of the bulbs, and the changes of this variable climate in September and October, the profits were very precarious, occasionally ruinous; which gave rise to habits of habitual discontent, and it may be inferred that the word 'croaker,' now a common appellation for a grumbler, was so derived."

7 or 8 cm. in length but the portions present in the drug seldom exceed 1 cm. Each stigma is about 25 mm. in length and has the shape of a slender funnel the rim of which is dentate or fimbriate.

Substitutes and Adulterants.—From the earliest times adulterated saffron and saffron substitutes have been found in commerce. During the Middle Ages the laws against adulterating the drug were particularly harsh and cases are on record of the culprit being burned at the stake or buried alive.

Examination of the soaked drug with a lens or with the low power of a microscope may show the presence of the following:—

(a) *Foreign Flowers or Petals.*—These can usually be detected without difficulty, alone or when mixed with the genuine drug. Compositous florets such as those of *Calendula officinalis* (feminell or Chinese safflower), *Carthamus tinctorius* (safflower or Indian safflower),* *Arnica montana* and *Onopordon sibthorpium* may be present in their natural state or artificially coloured. The flowers of *Lyperia atropurpurea* (Scrophulariaceæ) were imported at one time under the name of Cape saffron.

(b) *Saffron Styles.*—These can be observed by their yellow colour and cylindrical shape and an excessive quantity must be regarded as an adulterant. The U.S. National Formulary limits their amount to 10 per cent. of the whole drug.

(c) *Saffron Stamens.*—These are of fairly regular occurrence in some Continental samples of the drug, the stigmas being mixed with from 10 to 50 per cent. of the stamens according to the price at which the drug is to be sold. This is not an adulteration in the ordinary sense as the buyer is not prepared to pay the price of the genuine drug and is aware that he is being supplied with an inferior grade. In the genuine drug the upper end of the stigma bears papillæ about 150μ long, among which are a few almost smooth-coated pollen-grains 40 to 75μ in diameter. The presence of stamens will, of course, much increase the number of such grains present.

(d) *Stigmas of Crocus vernus.*—These differ from those of *Crocus sativus* in that they are shorter, more divided at the apex, and orange in colour.

* These are often made into cakes with a sugary substance and sold as cake saffron (*Croci placenta*).

Genuine samples of saffron should respond to the following tests:—

1. When sprinkled on the surface of concentrated sulphuric acid each piece of saffron gives a deep blue colour to the surrounding acid. This reaction is given by several substances present in saffron (see below), by carotin, and by the petals of the South African plant, *Crocus aurea*.

2. No oily stain should be left when the drug is pressed between sheets of unglazed paper (absence of added vegetable or mineral oil).

3. Saffron gives little colour to ether or petroleum spirit. The colouring matter is, however, soluble in water 0.1 G. of the drug giving to 50 ml. of water a yellow colour of the same shade and intensity as that given by 0.275 G. of chromic anhydride to a similar volume of water. These tests serve to detect exhausted saffron or other substances which have been coloured with artificial colouring matters.

4. Saffron yields about 5 to 7 per cent. of ash. An excess of ash indicates added inorganic matter, which may be artificially coloured.

5. Saffron contains about 9 to 14 per cent. of moisture and yields about 50 per cent. of aqueous extractive. Excessive amounts of the latter indicate adulteration with sugars, honey, glycerin, glyceryl borate, or soluble salts. The determination must be done so as not to overlook ammonium salts, which would be volatilised by overheating.

6. The nitrogen content of saffron is remarkably constant at about 2.22 to 2.43 per cent. and a Kjeldahl estimation is therefore a good test of purity.

Constituents.—Saffron contains red colouring matters of glycosidal nature, a colourless crystalline glycoside called picrocrocin (Kayser, 1885), a trace of volatile oil, wax, and inorganic matter.

An impure form of the colouring matters now known as crocin was formerly known as polychroite. Karrer (1927) by treating crocin with a cold dilute solution of potassium hydroxide isolated two reddish, crystalline substances and by acidifying the mother liquor obtained some bluish-red crystals. These three substances are known respectively as β -, γ -, and α -crocin. Crocin and the three crocins all give a blue colour on treatment with concentrated sulphuric acid. As mentioned previously, this reaction is also given by carotin, and the petals of *Crocus aurea*.

Uses.—Saffron exerts no therapeutic action but is still popularly credited with medicinal properties. It is used in pharmacy to a limited extent as a colouring and flavouring agent. In Cornwall and other parts of the country it is used for making saffron cakes.

IRIDIS RHIZOMA

Orris Rhizome, Orris Root ; F. Iris ; G. Viole wurzel, Veilchenwurzel

Source.—Orris rhizome is obtained from three species of *Iris*, namely, *I. florentina*, found in Northern Italy; *Iris germanica*, found in Northern Italy, France, Central Europe, Morocco, and Northern India; and *Iris pallida*, found in Italy (Florence and Lucca) and Eastern France. The chief varieties in English commerce are known as Florentine and Veronese, the former being usually preferred. It is obtained not only from *Iris florentina* but also from *I. germanica* and *I. pallida*, all three species being cultivated in the neighbourhood of Florence. Some of the drug grown around Verona comes into commerce via Florence and is sold as Florentine. Orris is also produced in Morocco and exported from Mogadore and Safi, in the Department of Ain in Eastern France, and in Northern India. The French drug is obtained from *I. pallida*, the African and Indian from *I. germanica*.

History.—Orris root has been used in perfumery from Greek and Roman times. Florence was an important source of the drug in the Middle Ages, the ancient arms of that city being a white iris on a red shield.

Collection and Preparation.—The plants are dug up in August and September, a period when the cork can be easily removed. The rhizomes are usually three years old when dug up, older rhizomes showing a tendency to rot at the ends. The aerial leaves and the roots are cut off and the rhizomes peeled. When fresh the rhizomes are practically odourless and have an acid taste, the characteristic fragrant odour only being developed on slow drying. The peeled rhizomes are dried in the sun for about five days either on matting (Florentine) or threaded on cords (Veronese). They are afterwards spread out in a cool, dry place for a week or so and then sorted by hand.

Characters.—Florentine orris occurs in dorsi-ventrally flattened pieces about 5 to 10 cm. in length and 2 to 3 cm. in diameter. The drug is whitish in colour, and having been peeled is free from cork. If the plant has flowered, which it usually does in the third or fourth year, the apex shows the remains of the flowering shoot and one or two short lateral branches terminating in cup-shaped scars. The age of the

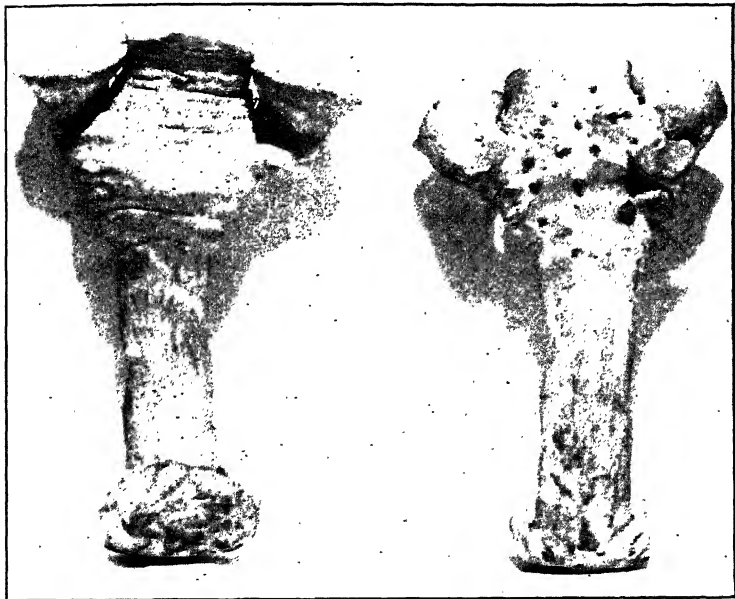


FIG. 79.—Upper and lower surface of the same piece of orris rhizome (Newman).

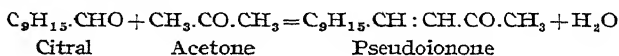
rhizome is indicated by the number of constrictions which represent the regions of winter growth. On the upper surface are lines of small vascular bundles left by the leaves, and on the lower surface are numerous root scars. Odour, pleasantly aromatic; taste, bitter.

The Veronese rhizomes closely resemble the above but may be rather more yellowish and wrinkled. They often bear holes through which cords have been threaded for drying purposes.

Mogadore orris is usually inferior to the European, the rhizome being smaller, darker, and less fragrant. The peeling is incomplete and the drug bears patches of reddish cork and the remains of leaves.

Orris root breaks with a short fracture and shows a narrow cortex (about 2 mm.) separated by a brown line, the endodermis, from the stele. The latter shows numerous, scattered vascular bundles. The cells of both cortex and stele contain abundant starch and prismatic crystals of calcium oxalate.

Constituents.—Orris rhizome contains volatile oil and non-volatile fatty bodies, which are, however, carried over during steam distillation. About 0.1 to 0.2 per cent. of this mixture is obtained by steam distillation and is termed oil or butter of orris. Tiemann and Krüger (1893) extracted the roots with ether, evaporated and steam distilled the residue. They found the non-volatile portion to contain a little myristic acid, whilst that volatile in steam contained myristic acid and its methyl ester, oleic acid and its esters, oleic aldehyde and a compound called irone. The latter substance, when somewhat diluted, has an intense odour of violets. Ionone, a substance isomeric with irone, is a well-known artificial perfume with an odour resembling that of violets. It is prepared by condensing citral with acetone to form pseudoionone, which on heating with dilute sulphuric acid is converted by isomeric change into ionone.



Orris rhizome also contains starch, calcium oxalate, a brown resin, a small proportion of tannin and a crystalline glycoside called iridin.

Uses.—Powdered orris root is used in dusting powders and in dentifrices, whilst the oil is used in perfumery not only for its delicate odour but as a fixative for artificial violet perfumes.

Order SCITAMINÆ

An order including the families Musaceæ (banana family), Zingiberaceæ, Cannaceæ, and Marantaceæ. Flowers hermaphrodite, zygomorphic or asymmetric. Floral formula $P_3+3, A_3+3, G(\bar{3})$. In most cases only one stamen is fertile, the remainder being represented by staminodes. Fruit a berry

(e.g. banana), or capsule (e.g. cardamom). Seeds with little endosperm, but abundant perisperm.

Family

The family Zingiberaceæ consists of 24 genera and about 300 species. Perennial herbs, chiefly from tropical Asia. Of economic importance are *Zingiber officinale* (ginger), *Elettaria Cardamomum* (true cardamom), *Curcuma domestica* (turmeric), *Curcuma angustifolia* and *C. leucorrhiza* ("East Indian arrow-root"), and *Aframomum Melegueta* (grains of paradise). The presence of aromatic and pungent principles is a notable feature of the family.

ZINGIBERIS RHIZOMA

Zingiber, B.P., *Radix Zingiberis*; Ginger; F. *Gingembre Blanc*; G. *Ingwer*

Source.—Official ginger is the rhizome of *Zingiber officinale* Roscoe, which has been scraped and dried in the sun. The species of *Zingiber*, of which about 70 are known, are reed-like plants. *Zingiber officinale* is grown in many parts of the world, including Jamaica, India, and Africa, but the official drug is that "known in commerce as unbleached Jamaica ginger." In the U.S.P. X, Indian-grown ginger (Cochin ginger) and African ginger were included in addition to the Jamaica variety, but the U.S.P. XI admits the Jamaican only.

History.—Ginger has been cultivated in India from the earliest times, the plant indeed being unknown in the wild state. The spice was used by the Greeks and Romans and was a common article of European commerce in the Middle Ages. It was well known in England in the eleventh century, Ginger was introduced into Jamaica and other West Indian Islands by the Spaniards, and a considerable quantity of the drug was sent from the West Indies to Spain as early as 1547.

Cultivation and Preparation.—The following details of the cultivation and preparation of Jamaica ginger are given by Harris :—*

"The virgin soil of the forest produces the best ginger, but a well-drained, clayey loam is suitable, and the rainfall must be abundant—80 ins. and upwards per annum, with a temperate climate. Pieces of

* Harris, P.J., 1909, September 18, 379. From the Bulletin of the Department of Agriculture, Jamaica. See also "Ginger, its Cultivation, Preparation and Trade," *Bull. Imp. Inst.*, 1926, 24, 667.

rhizomes, each containing an 'eye' or bud, are planted a few inches below the surface in holes or trenches in March or April. 'Plant' ginger is harvested during December and January, but 'ratoons'* may be gathered from March to December. The rhizomes are ready for digging when the stems wither, which takes place soon after flowering."

"When the rhizomes are dug, they are peeled with a knife specially made for the purpose. This operation requires much care and experience. As a rule, experienced operators peel between the 'fingers' of the rhizomes, the other portions being peeled by less experienced workers. This work is always done by women and children. As fast



FIG. 80.—Peeling ginger (Jamaica), B.W.I. (From the Imperial Institute Collection.)

as peeled the rhizomes are thrown into water and washed, the purer the water and the more freely it is used the whiter will be the product. The ginger peeled during the day is allowed to remain in the water overnight."

"After washing, the rhizomes are spread out on barbecues or on mats in the sun early in the morning. They are turned during the day, and are taken under cover during cloudy or rainy weather and at night, as if allowed to get damp they become mouldy. The drying process

* "Ratoon" ginger is that which is obtained by leaving a portion of the rhizome in the ground when the first crop, the "plant" ginger, is collected. It is usually small, greyish-brown in colour, and imperfectly peeled.

occupies five to six days, and during this period the ginger loses about 70 per cent. of its weight. After drying it is bleached by washing, and again dried for two days, when it is ready for shipping."

Gingers are also found in commerce from which little or no cork has been removed (see below). These "coated" or "unscrapped" gingers are sometimes whitened by means of

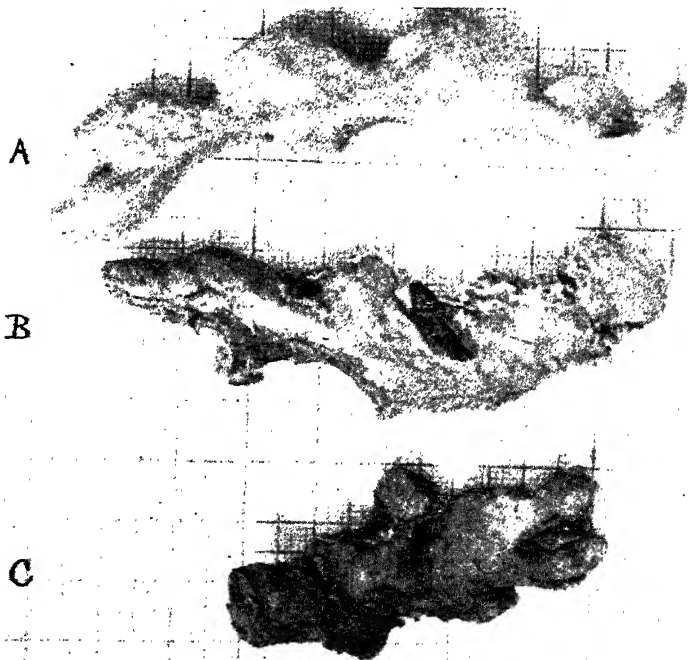


FIG. 81.—Gingers. A, Jamaica ; B, Cochin ; C, African (Newman).

chemicals such as sulphurous acid or chlorine, or are dusted with calcium carbonate or sulphate to improve their appearance. Gingers are also sometimes limed both abroad and in London to minimise insect attack. The official drug, however, is sun-bleached only—heavily limed samples would yield more than the officially permitted percentage of ash.

Macroscopical Characters.—The dried drug shows little

resemblance to the fresh rhizome owing to loss in weight and shrinkage. It occurs in sympodially branched pieces known as "hands" or "races." These are 7 to 15 cm. long, 1 to 1.5 cm. broad and laterally compressed. The branches arise obliquely from the rhizome, are about 1 to 3 cm. in length and terminate in depressed scars or in undeveloped buds. The

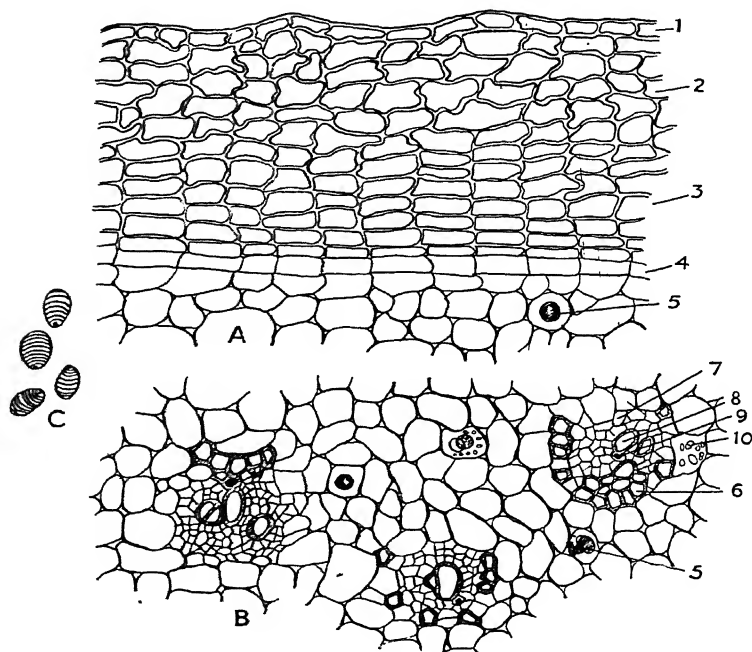


FIG. 82.—Ginger rhizome. A, transverse section of outer region; B, transverse section through three fibro-vascular bundles; C, starch. 1, epidermis; 2, hypodermis; 3, cork; 4, phellogen; 5, oil cell; 6, sclerenchymatous fibres; 7, phloem; 8, vessel; 9, resin cell; 10, starch-containing parenchyma. (After Tschirch-Oesterle, *Atlas*.)

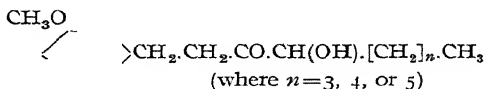
outer surface is buff-coloured and longitudinally striated or fibrous; it shows no sign of cork. The drug breaks with a short fracture, the fibres of the fibro-vascular bundles often projecting from the broken surface. It has an agreeable aromatic odour and a pungent taste.

In transverse section a lens shows: (a) cortex; (b) a dark line, the pericycle and endodermis (the latter without starch); and (c) the stele with numerous scattered fibrovascular bundles. Similar bundles also occur in the cortex. The bundles appear as greyish points, the smaller yellowish points which can also be seen being secretion cells.

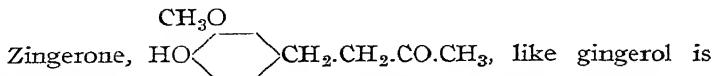
Microscopical Characters.—Microscopic examination of the section and of the powder shows that the parenchymatous ground tissue contains abundant and characteristic starch grains. These are almost entirely simple, ovoid or sack-shaped, 5 to 50 μ long, and have a very markedly eccentric hilum.* Ginger powder shows vessels with spiral or annular thickening and long, thin-walled fibres. Neither vessels nor fibres give any marked lignin reaction with phloroglucinol and hydrochloric acid. Narrow cells containing resin or pigment and oil cells with suberised walls may also be observed. Cork cells,† calcium oxalate and sclerenchymatous cells are entirely absent. For powder see p. 103.

Constituents.—Ginger contains from 0.25 to 2.0 per cent. of volatile oil and from 5 to 8 per cent. of resinous matter. Oil of ginger, to which the drug mainly owes its aroma, contains terpenes (*d*-camphene and β -phellandrene), a sesquiterpene (zingiberene), cineole, citral, and borneol.

The pungency of ginger is due to the "oleo-resin," gingerol, an oily liquid consisting of homologous phenols of the formula:



The pungency of gingerol is destroyed by boiling with 2 per cent. potassium hydroxide. Boiling with baryta water decomposes it with formation of a phenolic ketone called zingerone and aliphatic aldehydes (mainly normal heptaldehyde).



* According to Kimura and Watanabe, *J. Pharm. Soc. Japan*, 1929, 49, 62, Japanese ginger (derived from *Zingiber Mioga*) contains starch mainly in the form of compound grains. Single grains ellipsoidal or ovoid (20 to 40 μ in length) or round (10 to 25 μ in diameter). The eccentricity of the hilum is less than in the starch of *Z. officinale*.

† Ginger cork, which is found on the "coated" varieties, is yellowish or brownish and thin-walled.

pungent but possesses in addition a sweet odour.* It is a crystalline substance, sparingly soluble in water, freely soluble in dilute alkalis and in most organic solvents. Its pungency is destroyed by prolonged contact with 5 per cent. sodium hydroxide. Zingerone is related to vanillin and has been prepared from it synthetically.

Ginger also contains resinous matter, starch, and mucilage. It yields about 3 to 5 per cent. of ash, and 12 to 15 per cent. of alcohol-soluble extractive.

Unofficial Varieties.—The plant which yields official Jamaica ginger is grown in many tropical countries, including India (Cochin, Calicut, and Bengal), Africa (Nigeria, Sierra Leone), the East Indies, Cochin China, Australia, and Florida. The chief unofficial varieties in English commerce are the Nigerian, Cochin and the African.

Nigerian ginger.—In recent years ginger grown in Nigeria, from plants imported direct from Jamaica, has been arriving on the English market in considerable quantities. It closely resembles the official Jamaica drug but can be distinguished from it in the whole condition by its somewhat darker colour, smaller size and that it is rather less deeply scraped. Nigerian ginger has a more pungent taste than Jamaican and yields less volatile oil (about 0.7 to 1.0 per cent.).† The drug yields less water-soluble ash than the Jamaican, often being below the pharmacopoeial requirements. It has been stated that this is due to prolonged washing of the rhizomes.

Cochin ginger, which is grown in southern India, is imported *via* Bombay or Madras. It occurs in both coated and scraped forms. The coated variety bears on the upper and lower surfaces a wrinkled reddish-grey cork which readily exfoliates. The lateral surfaces are without cork but are decidedly darker than the surface of the Jamaican drug. Pieces may be found of almost exactly the same size and shape as the Jamaican, but on the whole the pieces are smaller and the branches somewhat thicker. Cochin ginger is more starchy and breaks with a shorter fracture than the official; it is equally pungent, but less agreeably aromatic. *Calicut ginger* closely resembles the Cochin, but the latter is usually regarded as the better grade.

African ginger is typically smaller and darker than the

* It is interesting to note that the methyl gingerols and methyl gingerone differ from gingerol and gingerone in being non-pungent.

† Meek, *Y. B. Pharm.*, 1937, 484.

Cochin. It is "coated," a brown cork extending over a greater area than in the Cochin. The relatively small exposed portions of cortex on the lateral sides are grey to blackish in colour. The quality of this drug has improved in recent years, but it lacks the fine aroma of the Jamaica drug although exceeding it in pungency. *Bombay ginger* resembles the African.

Allied Drugs.—*Japanese ginger*, which is said to be derived from *Zingiber Mioga*, occurs in small coated pieces. The volatile oil which it contains differs in physical properties from that of the official species and gives the drug a bergamot-like odour. The taste is less pungent than that of *Z. officinale*. The starch grains are compound and less eccentric than those of the official drug.

Martinique ginger is said to be derived from *Zingiber Zerumbet* Rose.

Preserved ginger consists of young, undried rhizomes, which are preserved by boiling in syrup. The West Indian variety is made from the official plant, but that from China is said to be obtained from the greater galangal, *Alpinia Galanga* (Fam. *Zingiberaceæ*). The latter species also yields *Siamese ginger*.

Galangal rhizome, now little used in England although employed on the Continent, is derived from the lesser galangal, *Alpinia officinarum*.

Adulteration.—Most of the likely vegetable adulterants can be detected by a routine microscopical examination. Powdered ginger may have been prepared from unscraped ginger or from "wormy" drug, and particular attention should, therefore, be paid to the absence of corky and insect remains fragments.

Adulteration may also take the form of the addition of "spent ginger," which has been exhausted in the preparation of essence. This may be detected by the official tests for purity. Official ginger yields about 7 (not less than 4.5) per cent. of 90 per cent alcohol-soluble extract; from 12 to 15 (not less than 10) per cent. of water-soluble extract; about 3 to 5 (not more than 6) per cent. of ash, and not less than 1.7 per cent. of water-soluble ash.

Exhausted ginger and, more particularly, ginger galenicals may have their pungency increased by the addition of capsicum or grains of paradise. The suspected liquid, or a tincture prepared from the suspected powder, is heated in a water-bath with caustic alkali. The liquid is then evaporated, the residue acidified with hydrochloric acid, and shaken with

ether. Some of the ethereal solution evaporated on a watch-glass gives a residue which is not markedly pungent to the taste. This test depends on the fact that gingerol is more readily decomposed by alkalis than are capsaicin or paradol.

Uses.—Ginger is used as a carminative and stimulant. It is more largely used as a condiment than as a drug.

CURCUMÆ RHIZOMA

Curcuma; *Turmeric*; F. *Safran des Indes*; G. *Kurkuma*, *Gelbwurzel*

Sources and Preparation.—Turmeric is the dried rhizome of *Curcuma domestica* cultivated in India, China and Malaya. The primary and secondary rhizomes are dug up, steamed or boiled, and dried.

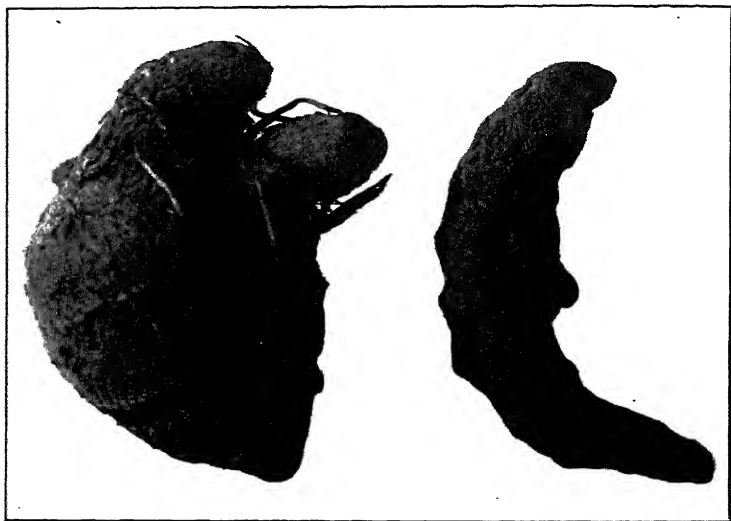


FIG. 83.—Turmeric "bulb" and "finger."

Characters.—The primary rhizomes are ovate or pear-shaped and are known as "bulb" or "round" turmeric, whilst the more cylindrical secondary, lateral rhizomes are about 4 to 7 cm. long and 1 to 1.5 cm. wide. The latter are known

as "fingers" and contain more yellow colouring matter than the bulb variety. Turmeric has an aromatic odour and a warm, somewhat bitterish taste.

Constituents and Uses.—Turmeric contains a yellow crystalline substance curcumin, about 5 per cent. of volatile oil, resin and abundant zingiberaceous starch grains. The latter are about 30 to 60 μ long and often gelatinised. Turmeric is used in curry powders and sauces, and paper impregnated with a turmeric tincture is used as a test for boric acid and borates.

CARDAMOMI FRUCTUS

Cardamomum, B.P., *Cardamomi Semina*; *Cardamoms*;
F. *Cardamomes*; G. *Cardamomen*

Source.—The official drug consists of the ripe, or nearly ripe, seeds of *Elettaria Cardamomum* Maton, var. *minuscule* Burkhill, which are directed to be kept in the capsules until required for use. The latter requirement facilitates recognition and helps to prevent loss of aroma. The drug is mainly obtained from cultivated plants grown in Ceylon and Southern India.

Elettaria Cardamomum is a reed-like plant attaining a height of 4 metres or more. It is the only species belonging to the genus *Elettaria*, but exhibits considerable variation and in addition to the variety *E. Cardamomum* var. *minuscule*, which yields the official drug, there is the variety *E. Cardamomum* var. *major* Thwaites, which yields the long wild native cardamoms of Ceylon (Fig. 84, E). In addition to these distinct varieties the official plant also shows variation, plants growing in Mysore differing in minor characters from those growing on the Malabar coast region. The Mysore-type plant has a more robust habit, bears larger and coarser leaves, has a more erect inflorescence, and stands exposure better than the Malabar-type. The Mysore-type has a short-branched, cream-coloured rhizome with pink markings. The leaves vary from 30 to 100 cm. in length. The flowers arise in loose racemes 50 to 60 cm. in length, each with 8 to 14 branches bearing 3 to 6 flowers. The fruits are capsules which open, when ripe, by three valves. The plants yield a small harvest in their third year, a full crop for the next six or seven years, and then start to decay.

At the present time the names of the commercial grades of fruit have not their former geographical significance as will be seen by consulting a map. The commercial grades now reaching London are :

1. *The Mysore or Ceylon-Mysore* (Fig. 84, A).—These,

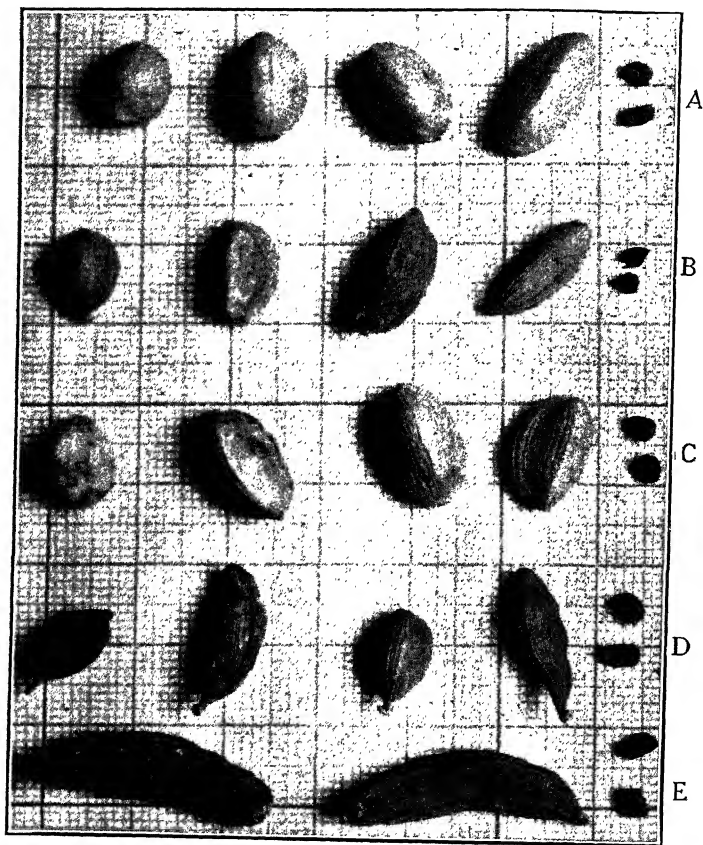


FIG. 84.—Cardamom fruits and seeds. A, Mysore ; B, Malabar ; C, Mangalore ; D, Alleppy green ; E, long wild native. (Newman.)

although bearing the name of an Indian state, are now mainly obtained from plants of the Mysore-type cultivated in Ceylon.

2. *Malabar or Ceylon-Malabar* (Fig. 84, B).—These derive their name from the Malabar Coast of S.W. India although



FIG. 85.—Gathering Cardamoms. (From the Imperial Institute Collection.)

largely obtained from plants of Malabar-type cultivated in Ceylon.

3. *Mangalore* (Fig. 84, C).—These are obtained from the district round the port of Mangalore on the Malabar Coast.

4. *Aleppi or Alleppy* (Fig. 84, D).—These take their name from a town in the native state of Travancore.

They are grown in Travancore and the neighbouring state of Cochin and are largely shipped from the port of the latter name.

History.—Cardamoms are mentioned in the early Sanskrit writings of Susruta, but it is difficult to say with any certainty when they first appeared in Europe. Immense quantities are still used in Hindoo festivals. Both *Amomum* and *Cardamomum* appear in a list of Indian spices liable to duty at Alexandria, about A.D. 176–180. The Portuguese navigator Barbosa (1514) appears to have been the first to mention the source of our official drug as the Malabar coast. Many so-called “cardamoms” have been imported at different times, and the *Amomum Verum* of many seventeenth-century pharmacopœias was a now obsolete Siamese “cardamomum” derived from *Amomum Cardamomum* Linn.

Collection and Preparation.—The cultivation of cardamoms varies in different districts and full details may be found in an excellent article in the *Chemist and Druggist*. The following account of the picking, curing, clipping, and grading of the fruits is taken from the same source :*

“ **Picking.**—In Ceylon the plants flower almost all the year round, but principally in January to May. Picking begins at the end of August and continues until April, October to December yielding most fruit. The flowers open in ones and twos at a time, the fruits also ripening successively, extending over a second season. In India the wasteful method of pulling off whole racemes is followed, but in Ceylon careful attention is given to picking. The capsules are cut off with short-bladed scissors before they ripen (they split if pulled off or are ripe), the slight turn of colour to yellow and the firmness of the fruit being the indications to the coolie expert. The first or maiden crops give the larger pods, while the earlier pickings also yield finer fruit. An average daily picking is 10 lb.”

“ **Curing** is effected in dry weather by exposure to the sun, but in hot weather over-exposure is guarded against, as over-heating causes the moist seeds to swell and burst the shell. Three hours’ exposure in the morning and two in the afternoon are sufficient in the heat. In unsettled weather advantage is taken of whatever sunshine there is. The proportion of split fruit is smaller the slower the drying. This operation is shown in Fig. 86 where trays of the fruit are placed on trestles. These can be readily covered when a shower threatens. In continuous wet weather slow drying is effected by gentle artificial heat on trays contained in racks in the curing-house, but the product

* “The Cultivation and Commerce of Cardamoms,” *C. and D.*, 1912, March 9, pp. 101–105.

is more brown in colour and accordingly less valuable. The house is arranged to allow ready egress of the trays, so as to take advantage

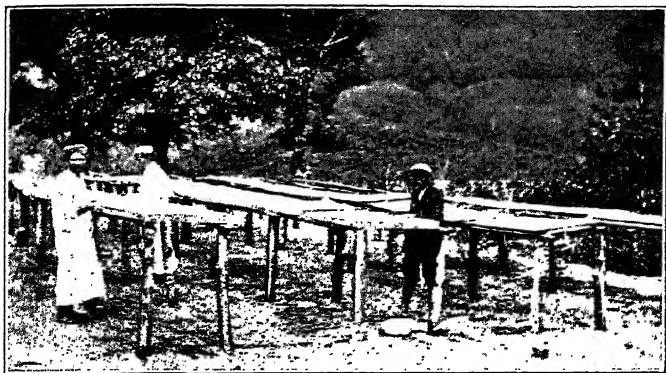


FIG. 86.—Curing Cardamoms (*Chemist and Druggist*).

of the sun's rays. The colour can be improved by sun-bleaching the capsules after sprinkling with water, but this considerably increases the proportion of split fruit."

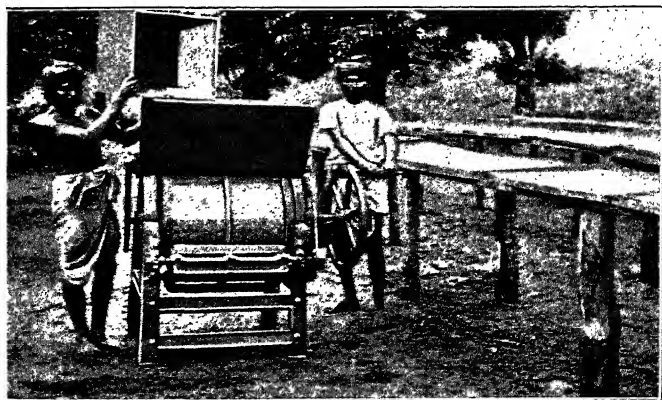


FIG. 87.—Clipping Cardamoms (*Chemist and Druggist*).

"Clipping and Grading.—The capsule still bears the remains of the calyx tube at the apex and the stalk at the base, and these were formerly removed by the tedious method of hand-clipping. Machines



FIG. 88.—Ceylon-Mysore cardamoms (natural size): "longs," "mediums," "shorts," and "tiny." (Redrawn from *Chemist and Druggist*.)

grading or three sizes, while sorting is also followed. Split fruit (averages about 10 to 15 per cent.), broken shell and seed are also sorted out. Our drawing (Fig. 88) shows, natural size, the types of Ceylon-Mysore cardamoms, known respectively as 'longs,' 'mediums,' 'shorts,' and 'tiny.' After sizing, the fruit is sulphured by placing in trays over burning sulphur (Fig. 89). The final operation is packing in cases for export, which is illustrated in our last photograph (Fig. 90)."

Macroscopical Characters.—The cardamon fruit is an inferior, ovoid or oblong capsule, about 1 to 2 cm. long. The size, shape and surface vary in the different commercial varieties and grades (see Fig. 88 and "Varieties"). The apex is shortly beaked and may show floral remains, whilst the base is rounded and shows the remains of the stalk. Internally the capsule is three-celled, a double row of seeds attached to axile placentas occurring in each cell. In good samples the seeds form about 70 per cent. of the total weight. The seeds in each loculus are tightly pressed together and usually separate in a single mass.

Each seed is about 4 mm. in length and 3 mm. in breadth and somewhat angular. The colour varies from a dark reddish-brown in fully ripe seeds to a much paler colour in the unripe ones. The testa is transversely wrinkled and is covered by a membranous aril. A groove on one side of the seed indicates the position of the raphe and a depression at one end the hilum. Cardamom seeds have a strongly aromatic odour and a pleasantly aromatic, although somewhat pungent, taste.

Varieties.—*Mysore* or *Ceylon-Mysore* (Fig. 84, A) are imported from Ceylon and constitute the chief commercial variety. They have a cream or pale buff colour and a nearly smooth surface.

Malabar or *Ceylon-Malabar* (Fig. 84, B) are usually smaller, and have a rather darker and less smooth pericarp than the *Mysore*.

Mangalore (Fig. 84, C) resemble the *Malabar*, but are usually more globular and have a rougher pericarp.

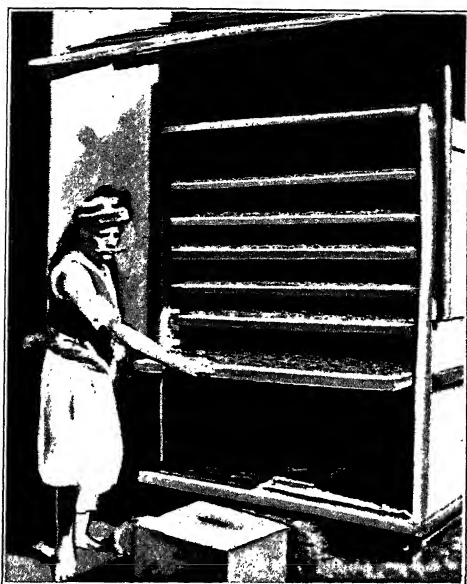


FIG. 89.—Sulphuring cardamoms (*Chemist and Druggist*).

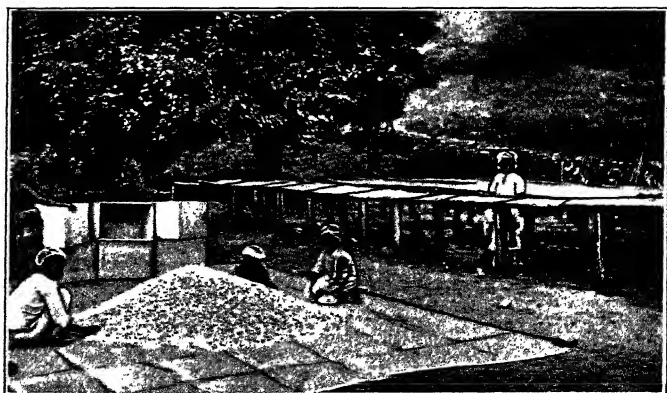


FIG. 90.—Drying and airing cardamoms for export (*Chemist and Druggist*).

Alleppy (Fig. 84, D) fruits are narrower than the other varieties, have a markedly striated pericarp, and vary in colour from greenish-buff to green.

The seeds of these varieties are almost indistinguishable from one another.

Microscopical Characters.—Sections of the seed (see Fig. 91) show a membranous aril, a brownish testa, a large white perisperm (grooved on one side), and a small, translucent, yellowish endosperm in which the embryo is embedded. The microscopic features of these layers are given in the Pharmacopœia.

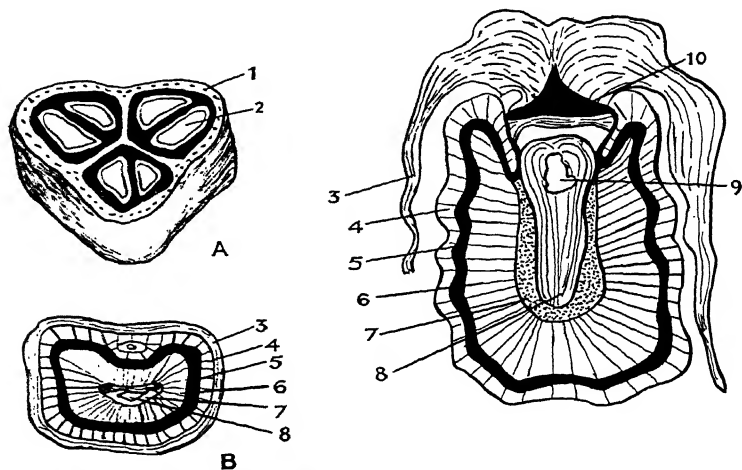


FIG. 91.—*Eleteria Cardamomum*. A, transverse section of fruit; B, transverse section of seed; C, longitudinal section of seed. 1, fibro-vascular bundles in pericarp; 2, seed; 3, arillus; 4, outer integument; 5, inner integument; 6, perisperm; 7, endosperm; 8, haustorium; 9, embryo; 10, embryonic cap. (After Tschirch-Oesterle, *Atlas*.)

The chief points to note are the long, narrow cells of the outer epidermis of the testa; the sclerenchymatous cells, each containing a nodule of silica, which form the inner layer of the testa; and the abundant thin-walled perisperm cells containing small starch grains and small prismatic crystals of calcium oxalate. For powder see p. 108.

The author understands that cardamom pericarps or husks which are periodically offered in the drug auctions are seldom bought openly, but the fact that they are eventually disposed

of privately makes it probable that they are used for purposes of adulteration. They may be identified in the form of powder by the pitted fibres and spiral vessels of the fibro-vascular bundles and by the abundant, empty parenchymatous cells.

Constituents.—Cardamom seeds are usually said to yield from 2 to 8 per cent. of volatile oil. Parry, who distilled genuine samples of Ceylon-Mysore and Ceylon-Malabar, obtained 2.6 per cent. from the former and 1.3 per cent. from the latter. Both oils had the same specific gravity but the Ceylon-Mysore oil had the higher optical rotation. The following figures are suggested as covering most pure samples of the oil: S.G. 0.923 to 0.945, optical rotation $+24$ to $+48^\circ$, refractive index 1.4620 to 1.4675, ester value 90 to 150. The oil contains a high proportion of terpinyl acetate, free terpineol and cineole.

The seeds also contain abundant starch and calcium oxalate. Ripe seeds yield about 3.5 to 5.5 per cent. of ash, and unripe seeds rather more (B.P. ash not more than 6 per cent.).

Allied Drugs.—*The long wild native cardamoms* of Ceylon (Fig. 84, E) are derived from *Elettaria Cardamomum* var. *major* Thwaites. They are much more elongated than the official variety, sometimes attaining a length of about 4 cm. The pericarps are dark brown and coarsely striated. The oil distilled from them is used in liqueurs. The following characters distinguish it from the oil of the official variety: S.G. 0.895 to 0.906, optical rotation $+12$ to $+16^\circ$, ester value 25 to 75.

No other similar drugs, unless we include grains of paradise which are described below, are imported in any quantity or with any regularity, and we therefore do no more than list a number of allied species the seeds of which somewhat resemble those of the true cardamom. They are:—

Amomum Cardamomum, the round or cluster cardamom of Siam and Java.

Amomum xanthioides, the bastard or wild Siamese cardamom.

Amomum aromaticum and *A. subulatum*, the Bengal and Nepal cardamoms.

Amomum maximum a Javanese plant.

Aframomum Korarima, the Korarima or Abyssinian cardamom.

Aframomum mala, the East African cardamom.

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Aframomum Hanburii and *A. Daniellii*, Cameroon cardamoms.

Aframomum angustifolium, Madagascar cardamom.

Costus speciosus, Chinese cardamom.

Uses.—The principal uses of cardamoms are as a flavouring agent in curries and cake. Large quantities are used in Scandinavia and Germany for this purpose. Some is used in the manufacture of liqueurs and a relatively small amount in pharmacy, chiefly in the form of Compound Tincture of Cardamom.

GRANA PARADISI

Grains of Paradise, Guinea Grains, Melegueta Pepper ; F. *Grains de Paradis, Maniguette* ; G. *Paradieskörner*

Source.—Grains of paradise are the seeds of *Aframomum Melegueta*, a reed-like herb 1.5 to 2 metres in height which is widely distributed in tropical West Africa. The fruit is much larger than a cardamom ; it has a thick, fleshy pericarp enclosing an acid pulp in which numerous seeds are embedded.

History.—The spice has been an article of commerce from very early times. It was originally conveyed overland to Tripoli, its exact geographical source being then unknown in Europe. In the fourteenth and fifteenth centuries direct trading with the West Coast of Africa commenced, and Columbus, who traded on the coast of Guinea, called it Costa di Maniguetta.

Characters.—The seeds are hard, reddish-brown, about 3 mm. in length, and of a somewhat flattened, pyramidal shape. The testa is papillose but at the more pointed end of the seed the fibrous remains of the funiculus are sometimes present.

Internally the structure resembles that of a cardamom seed ; a starchy perisperm surrounds a small yellowish endosperm in which the embryo is embedded. When crushed the seeds have an aromatic odour ; the taste is intensely pungent.

Constituents.—The pungency of grains of paradise is due to a yellow, oily substance, paradol (Thresh 1884), which Nelson (1917) has shown to be very closely related to gingerol. Both, for example, give a blue colour on mixing with vanillin and sulphuric acid and diluting with a little water. They differ, however, in that the pungency of paradol is little affected by

boiling with a 2 per cent. solution of potassium hydroxide, whilst that of gingerol is destroyed.

The spice yields 0.3 to 0.75 per cent. of volatile oil of S.G. 0.897. It has an ester value of 41.2 and an ester value after acetylation of 63.9.

Uses.—The seeds are now mainly used in veterinary medicine and to give pungency to alcoholic liquors. They are also said to be an adulterant of pepper.

Order MICROSPERMÆ

The order Microspermæ contains the two families Orchidaceæ and Burmanniaceæ.

Family ORCHIDACEÆ

The Orchidaceæ includes about 400 genera and 6,000 species. The plants are widely distributed and of varied habit ; many are epiphytes. The flowers are medianly zygomorphic and the seeds are without endosperm, points which distinguish this family from the Burmanniaceæ. The trimerous flowers are usually very conspicuous. They show considerable reduction in the androecium, only one or two stamens being fertile. The inferior ovary develops into a capsule which is usually unilocular and possesses three, double, parietal placentas on which the extremely minute seeds are borne.

VANILLÆ FRUCTUS

Vanilla ; *Vanilla Pods* ; F. and G. *Vanille*

Source.—Vanilla consists of the carefully-cured, fully-grown but unripe fruits of *Vanilla planifolia*. The fruits of other species, such as *V. Pompona* Schiede, are also used but to a much more limited extent.

Vanilla planifolia is largely grown, in a semi-wild state, in the woods of Eastern Mexico, its natural home. It has also been introduced into many oceanic islands and is now cultivated in Réunion (or Bourbon), Mauritius, Seychelles, Madagascar, Java, Ceylon, Tahiti, Guadeloupe, Martinique, and the Dutch East Indies.

History.—Vanilla was found in Mexico by the Spaniards, where it was used for flavouring chocolate, a use to which it is

still put. It found a place in the London Pharmacopœia of 1721.

In 1819 a cutting of *V. guianensis* was introduced from Cayenne (French Guiana) into Réunion. This was followed in 1822 by the introduction of *V. planifolia* into the same island. Until about 1841, owing to the absence of the insects necessary for pollination, the Réunion plants had no commercial use, but on the introduction of hand-pollination the cultivation of vanilla spread rapidly not only in Réunion but in other islands. The Bourbon vanilla of commerce, although largely grown in Réunion (Bourbon), is also obtained from Mauritius and Seychelles.

Cultivation.—Vanilla requires a warm and fairly moist climate. Propagation is simple, cuttings 1 to 3 metres long being attached to trees, *e.g. Casuarina equisetifolia*, where they soon strike roots on the bark. The plant is an epiphyte. It flowers at the end of two or three years and continues to produce fruit for thirty or forty years. The flowers are usually pollinated by women and children, a pointed stick being introduced into one flower after another. Each operator will pollinate about 800 to 1,000 flowers in a morning. Only a limited number of flowers on each plant are pollinated as it is found that this produces larger and better fruits.

Collection and Curing.—The fruits are collected when the upper part of the pod changes in colour from green to yellow. The characteristic colour and odour of the commercial drug are only developed as a result of enzyme action during the curing. The details of the latter process vary somewhat in different countries, but the following method is still used to a considerable extent although tending to be displaced by very slow drying in sheds which are kept at carefully regulated temperatures. The fruits are placed in baskets and immersed once, twice, or thrice in water at a temperature of from 70° to 85°. The duration of each immersion varies from 6 seconds to 2 minutes according to the temperature of the water and the number of dippings. The drained pods are packed in wool-covered boxes until the following day, when they are placed in thin layers between woollen blankets which are exposed to the sun during the heat of the day. As night approaches they are packed in wool-covered boxes. This procedure is repeated on each of the following days until the slow drying is completed. This curing takes from 15 to 60 or more days, according to the state of the weather.

Packing and Grading.—Before grading any pods showing a tendency to mould are picked out. The remainder are sorted into three or four grades according to quality, the pods of each grade being then sorted to size and packed in bundles of 50 pods, which are bound in three places. These are packed in tin cases or boxes holding about 10 or 12 kilograms, soldered up and packed in wooden cases. On arrival in London the tins are opened and the pods re-graded (Fig. 11). During the storage in London crystals frequently develop on the surface of the pods, except in the case of the Bourbon drug, on which they have usually appeared while they were in Paris. Pods of excellent quality sometimes develop no crystals.*

Characters.—Vanilla pods are 15 to 25 cm. in length, 8 to 10 mm. in diameter, and somewhat flattened. The surface is longitudinally wrinkled, dark brown to violet-black in colour, and frequently covered with needle-like crystals of vanillin. The fruits are very pliable and have a very characteristic odour and taste.

A transverse section of the fruit shows under a lens a pericarp divided into two unequal valves and a single cavity. Extending into the latter are three double parietal placentas to which numerous very minute seeds are attached. The cavity also contains a dark-coloured balsamic fluid secreted by the lining hairs (Fig. 92, B). The latter seen under the microscope are seen to contain globules of oil (Fig. 92, C). The pericarp has a diffuse ring of vascular bundles and in its parenchymatous cells are crystals of both calcium oxalate and vanillin in addition to much brown oleo-resinous matter.

Constituents.—According to Goris (1924) green vanilla contains three glycosides, namely, glucovanillin, glucovanillic alcohol, and a third which has not yet been isolated. During the curing these are acted upon by an oxidising and a hydrolysing enzyme which occur in all parts of the plant (Lecomte, 1903). Glucovanillic alcohol yields on hydrolysis glucose and vanillic alcohol; the latter compound is then by oxidation converted into vanillic aldehyde (vanillin). Glucovanillin, as its name implies, yields on hydrolysis glucose and vanillin. The third constituent yields no vanillin on hydrolysis but a strongly aromatic ester.

* Exhausted and redried vanilla pods are sometimes dusted with crystals of benzoic acid to render them more like the genuine drug. A genuine crystal mixed on a watch-glass with phloroglucinol and hydrochloric acid gives a carmine-red colour (distinction from benzoic acid).

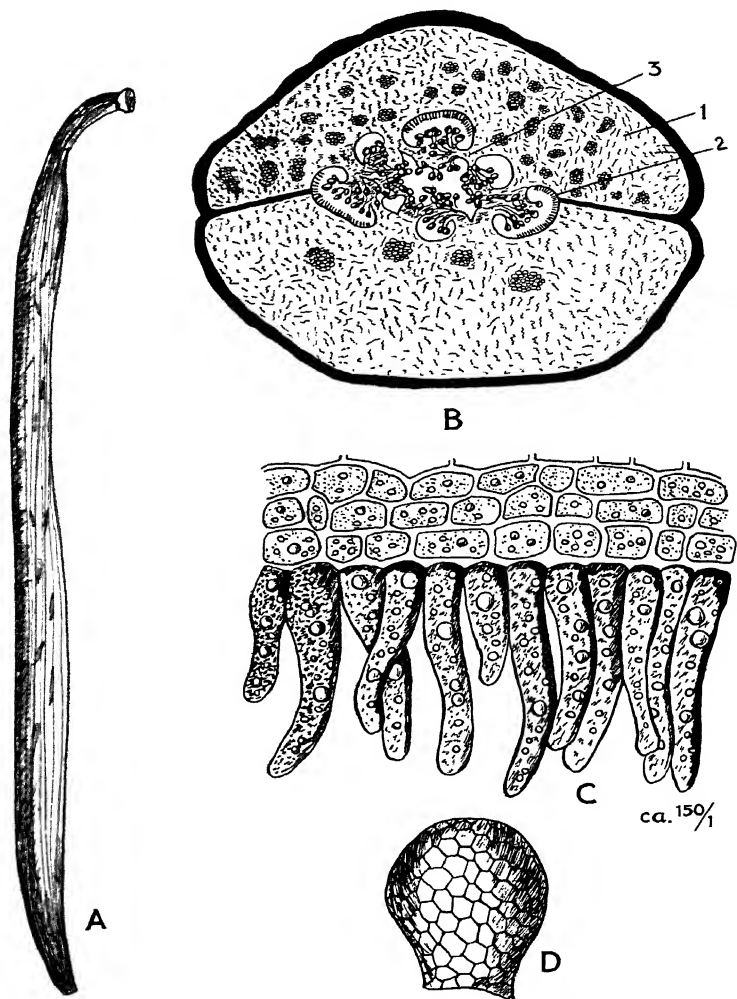


FIG. 92.—Vanilla. A, whole fruit ; B, transverse section of fruit ; C, secretory hairs ; D, seed. 1, fleshy pericarp ; 2, secretory hairs ; 3, placenta. (B to D after Gilg.)

The average amounts of vanillin present in the different commercial varieties are: Mexican, 1.30 to 1.80 per cent.; Bourbon, 0.75 to 2.80 per cent.; Javanese, 1.50 to 2.75 per cent.; Tahiti, 1.5 to 2.0 per cent.*

Vanillin is the aldehyde corresponding to methylprotocatechuic acid and has been synthesised in a number of ways. Large quantities of it are prepared from eugenol isolated from oil of cloves. Vanillin occurs in several balsamic drugs, e.g. balsam of Peru and storax, and in the seeds of the white lupin.

Uses.—Vanilla pods are widely used in confectionery and in perfumery. They have been replaced to some extent, but by no means completely, by synthetic vanillin. The latter fails to represent the odour and flavour of the whole pods.

* There appear to be three kinds of Tahiti vanilla derived respectively from plants of true *Vanilla planifolia* type, from *V. planifolia* var. *angusta*, and from *V. Tiarei*.

CHAPTER XIX

Phylum **ANGIOSPERMÆ** ; Subphylum **DICOTYLEDONS**

Grade A. **Monochlamydeæ**

Order **SALICALES**

Family **SALICACEÆ**

THE Salicaceæ is the only family in the Salicales and consists of two genera, namely, *Salix* and *Populus*. There are about 160 species of *Salix* (willows, osiers, and sallows), and some 30 species of *Populus* (poplars). The flowers are dioecious and occur in catkins, those of the willows being erect and those of the poplars pendulous.

Glucosides such as salicin and populin (benzoylsalicin) occur in the bark, leaves, and buds of many species. The internal bud scales of the poplar have glandular surfaces which secrete balsam (*Populi Gemmæ* N.F., Balm of Gilead Bud). Willow charcoal is the chief form of wood charcoal used in this country, and the proprietary French charcoals are generally prepared from young poplar shoots.

SALICIS CORTICES

Willow Barks ; *F. Écorce de Saule* ; *G. Weidenrinde*

Source.—White willow bark is obtained from *Salix alba*, and black willow bark from *Salix discolor* (the pussy willow) and *S. nigra*. Both black and white willow barks are commercial articles although now but little used in pharmacy. Most of the species of *Salix* which have been examined contain salicin, but the principal commercial sources of this glucoside appear to be *S. fragilis* and *S. purpurea*, which are largely grown in Belgium for basket-making and yield a thin reddish bark known as “rood schors.”

Characters.—White willow bark usually occurs in channelled pieces 10 or more cm. long, 1 to 2 cm. wide, and about 1 mm. thick. Such bark is smooth or only slightly wrinkled on the outer surface, but older bark is rugged and thicker. The outer surface is greyish-brown while the inner surface is of a pale reddish colour and finely or coarsely striated according to age.

Black willow bark from *S. discolor* occurs in long, very thin, fibrous strips. It has a brownish or greenish-brown, wrinkled cork and a reddish-brown inner surface. The bark of *S. nigra* resembles it but is somewhat darker and thicker.

Willow barks develop a few layers of cork cells each year, the outer tangential walls of which are sclerosed. The outer part of the primary cortex is collenchymatous. In young barks a ring of pericyclic fibres is found, but later this ring bursts and isolated groups of fibres are found. Groups of sclerenchymatous fibres occur in the phloem surrounded by crystal-fibres containing numerous single crystals of calcium oxalate. Cluster crystals occur in the cortex and phloem.

Constituents.—With the exception of *S. discolor* (which contains the glucoside salinigrin) most of the other species of *Salix* examined contain salicin. It is also present in some poplars, e.g. *P. tremula* and *P. tremuloides*, together with the glucoside populin (benzoylsalicin). The amount of glucoside present appears to be subject to considerable seasonal variation, the bark of *S. sitchensis* containing 7.38 per cent. when gathered in the spring and 2.80 per cent. when collected in the autumn. The approximate salicin content of other species is as follows: *S. purpurea*, 6 to 7 per cent.; *S. fragilis*, 3 per cent.; *S. nigra*, 0.7 per cent.; and *S. alba*, 0.6 per cent. Willow barks also contain a considerable amount of tannin and have in fact been employed for tanning leather. Willow barks give tests for phlobatannins.

Preparation of Salicin.—The glucoside and tannin are extracted from the bark by macerating it in hot water for some hours. The liquid is filtered, concentrated *in vacuo* and treated in turn with lime, lead acetate and basic lead acetate. The filtered liquid, which is now free from tannin, is concentrated and then allowed to cool, when crystals of salicin separate. These crystals may be purified by dissolving them again, filtering through animal charcoal, and recrystallising.

Tests for Salicin.—For the general characters of salicin the student is referred to the Pharmacopœia. The following tests should be carried out:—

belong to the genus *Quercus* (oak). Other important genera are *Fagus* (beech) and *Castanea* (chestnut). The flowers are monœcious except in *Nothofagus*. The flowers of *Quercus robur* (Fig. 93), are typical of the family. The fruits are surrounded by a cupule.

The phellogen arises in the outermost layer of the primary cortex. In *Quercus* the cork cells are mostly flat and thick-walled. A peculiar feature of some species, e.g. *Quercus suber*, an important cork-yielding species, is the sclerosis of the inner portions of the primary medullary rays. A ring of

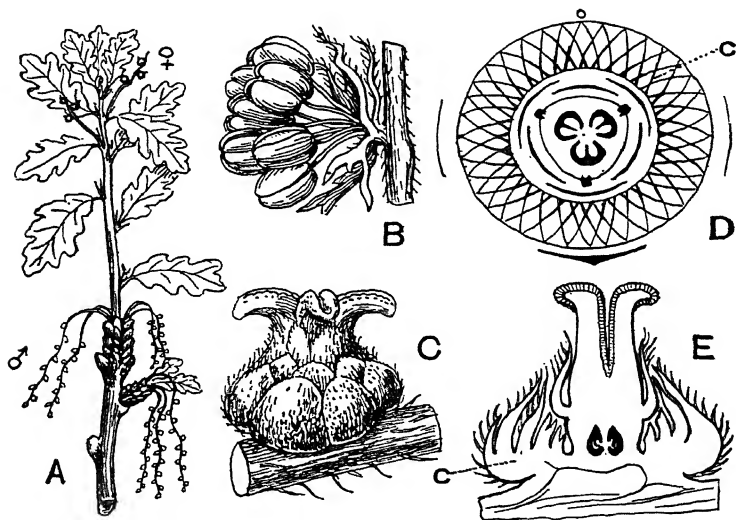


FIG. 93.—*Quercus robur*. A, shoot bearing male, ♂, and female, ♀, inflorescences. B, male flower; C, female flower; D, diagram of female flower; E, longitudinal section of female flower; c, cupule. (From Rendle's *Classification of Flowering Plants*.)

sclerenchyma is present in the pericycle and both single and cluster crystals of calcium oxalate are usually found.

QUERCUS CORTEX

Oak Bark; F. *Écorce de Chêne*; G. *Eichenrinde*

Source.—The oak bark of the B.P. 1885 consisted of the dried bark of the smaller branches of *Quercus robur*. In

America the bark of the indigenous white oak, *Q. alba*, is included in the National Formulary.

Characters.—Young oak bark occurs in channelled pieces or quills up to 20 cm. in length and 3 cm. in breadth. The exterior bears a silvery-grey cork which in younger pieces is marked with brown lenticels. Internally the bark is well characterised by the cinnamon-brown or reddish-brown colour and the very marked, longitudinal fibres. Oak bark has a very astringent taste and responds to tests for phlobatannin, ellagitannin and gallic acid.

Constituents.—Young oak bark contains about 15 to 20 per cent. of tannin and old bark from 5 to 10 per cent. This appears to consist chiefly of an amorphous phlobatannin (quercitannic acid), which when boiled with dilute sulphuric acid is converted into a reddish-brown phlobaphene, oak-red. The bark also contains gallic acid and, according to Ware, a little ellagitannin.

Uses.—Oak bark is used to a limited extent as an astringent, but its main use is as a tanning material.

GALLA QUERCINA

Galla ; *Galls* ; *Aleppo*, *Turkey*, or *Syrian Galls* ; *Nutgalls* ;
F. Galle d'Alep ; *G. Galläpfel*, *Gallen*

Source.—Turkish galls are vegetable growths formed on the young twigs of the dyer's oak, *Quercus infectoria* Olivier, as a result of the deposition of the eggs of the wasp, *Cynips gallæ tinctoriæ* Olivier.

The dyer's oak is a small tree or shrub about 6 feet in height which is found in Asia Minor, Syria, Persia, Cyprus, and Greece. Excellent illustrations of the insect *Cynips gallæ tinctoriæ* and the stages in the formation of galls are given by Tschirch. The insect, by means of its ovipositor, punctures the young tissue of an oak bud and deposits an egg in the wound. It was formerly thought that the subsequent abnormal development of vegetable tissue round the larva was due to the introduction of some substance by the ovipositor. According to Cosens, however, this is due to an enzyme-containing secretion, produced by the young insect after it has emerged from the egg, which by the rapid conversion of

starch into sugar stimulates cell-division. As starch disappears from the neighbourhood of the insect, shrinkage occurs and a central cavity is formed in which the insect passes through the larval and pupal stages. Finally, if the galls are not previously collected and dried, the mature insect or imago bores its way out of the gall and escapes. During these changes the colour of the gall passes from a bluish-grey through olive-green to almost white.

Galls are collected by the peasants of Asia Minor (particularly in the province of Aleppo) and Syria. After drying in the sun, during which they lose about 50 per cent. of their weight, they are bought up by the exporters. The latter grade them according to colour into the three grades blue, green, and white which are found on the London market.

History.—Galls were well known to the ancient writers and Pliny records the use of their infusion as a test for sulphate of iron in verdigris, possibly the earliest mention of an attempt to detect adulteration by chemical means.

Macroscopical Characters.—Aleppo galls are globular in shape and from 10 to 25 mm. in diameter. They have a short, basal stalk and numerous rounded projections on the surface. Galls are hard and heavy, usually sinking in water. The so-called "blue" variety are actually of a grey or brownish-grey colour. These, and to a lesser extent the olive-green "green" galls, are preferred to the "white" variety in which the tannin is said to have been partly decomposed. White galls also differ from the other grades in that they show a circular tunnel through which the insect has emerged. Galls without this opening have insect remains in the small central cavity. Galls have a very astringent taste.

Microscopical Characters.—Sections through a gall show a very large, outer zone of thin-walled parenchyma, a ring of sclerenchymatous cells, and a small, inner zone of rather thick-walled parenchyma surrounding the central cavity. The parenchymatous tissues contain abundant starch, masses of tannin, rosettes and prisms of calcium oxalate, and the rounded, so-called "lignin-bodies," which give a red colour with phloroglucinol and hydrochloric acid.

Constituents.—Galls contain from 50 to 70 per cent. of the tannin known as gallotannic acid (*Acidum Tannicum*, B.P.). Gallotannic acid is a typical gallitannin (see p. 671) and the drug according to Ware contains no appreciable quantity of either phlobatannin or ellagitannin. Galls also contain gallic

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acid (about 2 to 4 per cent.), ellagic acid, starch, and calcium oxalate.

Fischer's investigations of gallotannin (from Chinese galls) show it to be pentadecagalloylglucose, a condensation product of one molecule of glucose with five molecules of digallic acid. Solutions of tannic acid tend to decompose on keeping with formation of gallic acid, a substance which is also found in many commercial samples of tannic acid. It may be detected by the pink colour produced on the addition of a 5 per cent. solution of potassium cyanide.

Extraction of Tannin.—The present British Pharmacopœia states that "Tannic acid may be obtained from the galls of various species of *Quercus*, by subjecting them to a special fermentation and extracting them with water-saturated ether." The last B.P. to give fuller details was that of 1885, which says:

"Galls in powder, ether, of each a sufficient quantity. Expose the powdered galls to a damp atmosphere for two or three days, and afterwards add sufficient ether to form a soft paste. Let this stand in a well-closed vessel for twenty-four hours, then, having quickly enveloped it in a linen cloth, submit it to strong pressure in a suitable press, so as to separate the liquid portion. Reduce the pressed cake to powder, mix it with sufficient ether, to which one-sixteenth of its bulk of water has been added, to form again a soft paste, and press this as before. Mix the expressed liquids, and expose the mixture to spontaneous evaporation until, by the aid subsequently of a little heat, it has acquired the consistence of a soft extract; then place it on earthen plates or dishes, and dry in a hot-air chamber at a temperature not exceeding 212° F."

It is said that commercial tannin is now very largely prepared by the use of acetone and other solvents and that much is prepared from Chinese and Japanese galls.

Allied Drugs.—Many different kinds of galls are known. They are generally produced on plants, but sometimes on animals. In addition to the large number produced by insects, particularly of the genera *Cynips* and *Aphis*, some are produced by fungi.

Chinese and Japanese galls are of considerable commercial importance. They are produced by an aphid, *Schlechtendaria sinensis*, on the petioles of the leaves of *Rhus javanica* (Anacardiaceæ). These galls are irregular in shape and partly covered with a grey, velvety down, the removal of which discloses a reddish-brown surface. They break easily and show a large, irregular cavity containing insect remains. They contain from 57 to 60 per cent. of tannin.

Crowned Aleppo galls are sometimes found in samples of ordinary Aleppo galls. They are about the size of a pea, are stalked, and bear a crown of projections near the apex. The insect inducing them is *Cynips polycera*.

Hungarian galls are produced by *Cynips lignicola* on *Quercus robur* growing in Yugoslavia. They are used in tanning. *English oak galls* contain about 15 to 20 per cent. of tannin.

Uses.—Galls are used as a source of tannic acid, for tanning and dyeing, and in the manufacture of inks. Tannic acid is used as an astringent and in the treatment of burns.

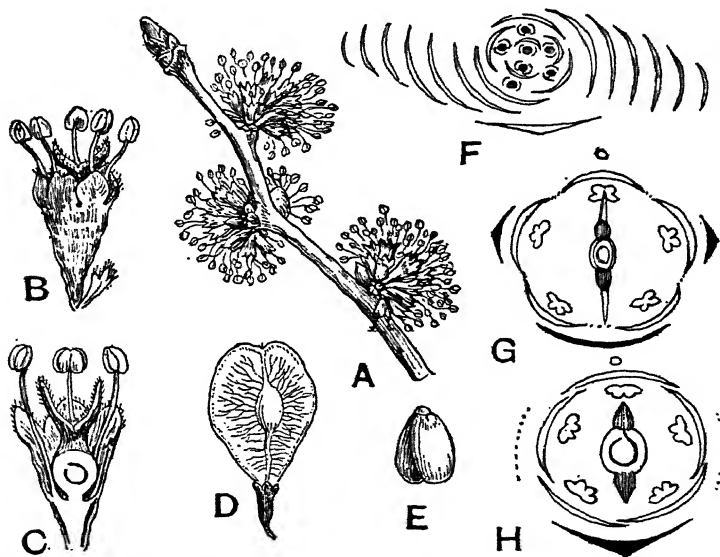


FIG. 94.—A–G, *Ulmus campestris*; A, flower-bearing twig; B, flower; C, same in longitudinal section; D, fruit; E, embryo; F, diagram of inflorescence; G, diagram of flower. (From Rendle's *Classification of Flowering Plants*.)

Order URTICIFLORÆ

The order Urticifloræ consists of four families: the Ulmaceæ, Urticaceæ, Moraceæ, and Cannabinaceæ. For the distinguishing characters of these families Rendle's *Classification of Flowering Plants* may be consulted.

Family **ULMACEÆ**

Thirteen genera and about 130 species. Trees or shrubs, without latex (distinction from Moraceæ). Cork is developed very artificially and consists of cells with wide lumina. Mucilage cells are found in the bast of many (but not all) species of *Ulmus*.

English elm bark, the bark of *Ulmus campestris* (Fig. 94), was formerly official and was used as a weak, demulcent astringent. It is still a commercial article and appears to be used as a domestic remedy. It contains less mucilage than slippery elm bark.

ULMUS FULVÆ CORTEX

Slippery Elm Bark ; F. Écorce d'Orme Roux ;

G. Ulmenrinde, Rusterrinde

Source.—Slippery elm bark is obtained from *Ulmus fulva*, a tree 15 to 20 m. in height which is widely distributed in the Northern parts of the U.S.A. and in Canada. The drug is mainly obtained from the regions round the Great Lakes.

In the spring fairly old bark is stripped from the trees. The outer part of the bark is then removed, only the inner part, which forms the commercial drug, being dried. After sawing this into convenient lengths it is bound into bundles with wire.

Characters.—The drug occurs in broad, flat strips about 50 to 100 cm. in length and from 1 to 4 mm. in thickness. A few reddish-brown patches of the imperfectly removed rhytidome may be seen, but the remainder consists only of secondary phloem. The outer surface is brownish-yellow and striated, the inner surface yellowish-white and finely ridged. The bark is easily identified by the characteristic, fenugreek-like odour, the strongly fibrous fracture and by the fact that it yields mucilage when moistened.

Powdered slippery elm bark is fawn-coloured. Under the microscope it shows numerous slightly lignified bast fibres, mucilage, prisms of calcium oxalate, and starch. Cork cells should be few or absent.

Inferior bark, possibly not always derived from *Ulmus fulva*, is sometimes seen in commerce. This cannot be folded lengthwise without breaking and is deficient in mucilage. If

10 grains of good quality bark in powder are shaken with a fluid ounce of water a thick jelly-like mass will form in 15 minutes. This may be used as a test to distinguish it from inferior qualities.

Constituents.—The chief constituent of the bark is mucilage. This is precipitated by lead acetate or lead subacetate, but not by alcohol. The tannin present has been estimated at 3 to 6.5 per cent.

Uses.—The mucilage present has demulcent, emollient, and nutritive properties. A poultice of the powdered bark is often used.

Family MORACEÆ

The family Moraceæ consists of about 60 genera and 1,000 species, almost all of which are trees or shrubs. Important genera are *Ficus* (700 species), *Morus* (mulberry), and *Artocarpus* (bread-fruit). Latex cells are found throughout the family (distinction from Ulmaceæ and Urticaceæ). The latex of *Ficus elastica* yields Assam rubber and that of *Castilloa elastica* yields Castilloa or Central American rubber. The latex of *Antiaris toxicaria*, the Upas tree of tropical Asia, is very poisonous. Cystoliths and long bast fibres are other characteristics of the family.

FICUS

Caricæ Fructus ; *Figs* ; *F. Ficus* ; *G. Feigen*

Source.—Figs are obtained from *Ficus Carica*, which is widely grown in the Mediterranean countries, particularly Asia Minor (Smyrna figs), Greece, and Spain. Figs are used in the preparation of Confection of Senna, where they are described as "figs of commerce."

Characters.—The fruit is produced by the union of the cymose inflorescence to form a hollow, fleshy axis bearing the flowers on its inner surface. In a young fruit, which is rich in latex, the bract of the main axis and the two bracteoles of its lateral branches may be seen at the base. Pollination is brought about by a gall-wasp. The flowers are unisexual and there are two kinds of female flowers, some long-styled (seed-producing flowers) and others short-styled (gall-flowers). In the seed-producing flowers the insect is prevented from laying

its eggs in the ovary by the stigmatic hairs, but the gall-flowers have eggs laid in their ovaries and are sterile.

In the mature fruit no latex is found and the fleshy axis is filled with sugar. The interior contains numerous small drupes and wasp eggs.

Constituents.—The fruits contain about 50 per cent. of glucose.

Family CANNABINACEÆ

This small family includes only three species, namely, *Humulus Lupulus* (common hop), *Humulus japonicus* (Japanese or Chinese hop), and *Cannabis sativa* (hemp). These plants are aromatic herbs with more or less palmately-divided leaves and persistent stipules. Both genera are normally dioecious, but the monœcious condition can be induced in both. The male flowers have five perianth leaves and five stamens, while the female ones have a small, cup-like perianth (perigone), a unilocular ovary, two conspicuous stigmas, and a single ovule. The fruit is a nut containing a curved (*Cannabis*) or rolled (*Humulus*) embryo and little endosperm.

Important microscopic features are the long bast fibres, which attain a length of 22 mm. in hemp (p. 142); the unicellular hairs, which often contain cystoliths; and the glandular hairs, the heads of which are usually divided by vertical walls only.

HUMULI STROBILI

Humulus; *Hops*; *F. Houblon*; *G. Hopfen*

1.—Hops are the dried strobiles of *Humulus Lupulus*. Only the pistillate plants are cultivated, large quantities being produced in England (particularly Kent), Germany, Belgium, France, Russia, and California. The strobiles are collected, dried in kilns and pressed into bales known as "pockets." They are sometimes exposed to the fumes of burning sulphur, treatment which is said to stabilise the aroma and colour.

History.—Hops were cultivated in England in the reign of William the Conqueror. For considerable periods their use in beer was not favoured and other plants were frequently used to give a bitter taste.

Characters.—The hop strobile is a cone-like structure about 3 to 4 cm. in length. It consists of membranous stipules and

bracts which are attached to a zigzag, hairy axis. Each small branch of the axis bears a bract, represented only by its pair of stipules, which subtends either four or six bracts, each enclosing a flower or fruit (Fig. 95, G). The stipules and bracts resemble one another closely, but only the latter enclose the immature fruits (achenes). On the fruits and bases of the bracts are numerous shining glands (Fig. 95, B and C). These when separated constitute the drug lupulin. *Humulus japonicus* bears no lupulin-glands.

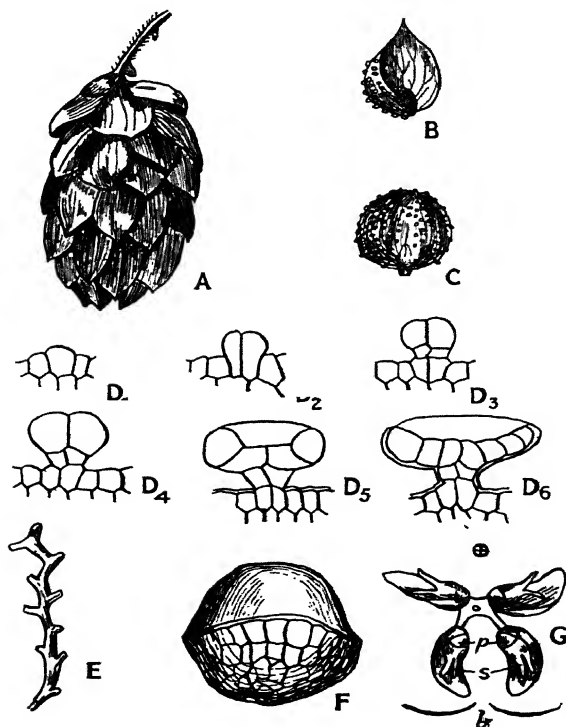


FIG. 95 — *Humulus Lupulus*. A, strobile; B, fruit in axil of a bract; C, fruit covered with lupulin glands; D1–D6, stages in the formation of a lupulin gland; E, fruit axis; F, mature lupulin gland; G, plan of female inflorescence, the bract (b) represented by its pair of stipules, subtending four flowers each with perigone (p) and stigmas (s). (A–C after Thoms, D and F after Rauter, G after Eichler.)

Lupulin of commerce is generally very impure owing to the fact that it is obtained by sieving the sweepings of the hop-room floors. It occurs as a granular, reddish-brown powder with a characteristic odour and bitter aromatic taste. It darkens on keeping, the odour becoming somewhat valerianaceous. Under the microscope glands such as those in Fig. 65, F, may be seen, each containing an oleo-resinous secretion which forces out the cuticle on one side. This secretion exudes if the gland is burst by applying pressure to the cover-slip. The drug also contains a considerable amount of sand and fragments of the bracts and stipules, which have wavy-walled epidermal cells.

Constituents.—The bracts and stipules of the hop contain tannin, but the odour and taste of the drug are mainly due to the very complex secretion contained in the lupulin glands. On distillation the fruits yield 0.3 to 1.0 per cent. of volatile oil, about 80 per cent. of which consists of an "olefinic" terpene and a sesquiterpene called "humulene." Deussen (1911) suggests that "humulene" is *i-a*-caryophyllene with a small amount of β -caryophyllene. The oil also contains esters of valericianic and other acids. The bitterness is due to a number of substances, one of which, humulol, has been obtained in crystalline form, while the valerian-like odour which develops on keeping is due either to the decomposition of one of the resins or to the hydrolysis of the valerianic esters of the oil.

Uses.—Hop pillows are sometimes used to promote sleep and an infusion is used as an aromatic bitter.

CANNABIS INDICA

Indian Hemp, Hemp, Guaza, Ganja; F. Chanvre de l'Inde; G. Indischer Hanf

Source.—The Indian hemp plant, although formerly considered to be a distinct species, is now regarded as a variety of *Cannabis sativa*, the common European hemp.* The drug consists of the dried flowering and fruiting tops of the pistillate plants from which no resin has been removed. The Indian-grown drug is largely produced under the control of the Bengal Government in the region north of Calcutta, cultivation also extending south-west through Central India to the neighbourhood of Bombay and southwards into the Madras Presidency.

* Planchon, *De Matière Médicale*, pp. 282-3, distinguishes three types of *Cannabis sativa*, namely, *var. vulgaris*, *var. sinensis*, and *var. indica*.

The drug is now also produced in East Africa (Zanzibar), South Africa, Tripoli, Asia Minor, and the U.S.A. (Texas, S. Carolina, etc.).

History.—Hemp has been cultivated for its seeds and fibres from a very remote period, but the narcotic properties are usually not marked in plants grown in temperate regions and even in India an active drug can only be grown in certain districts. The drug is mentioned in early Hindoo and Chinese works on medicine, and its use slowly spread through Persia to the Arabs. It was used by the Mohammedan sect known as the Hashishin or assassins who came into contact with the Crusaders in the eleventh and twelfth centuries. The drug attracted the attention of Europeans at the time of Napoleon's Egyptian expedition, but its introduction into Western medicine is mainly due to experiments made by O'Shaughnessy in 1838-39.

Production of Bombay or Flat-Ganja.—The drug used in England is known as *flat -or Bombay guaja*.* Its production is now confined to three small villages near the town of Ahmednagar, due east of Bombay. Police supervise the growing of the crop and the production of the drug. These villages supply drug for export and for use in the whole of the Bombay Presidency, and some of the Native States and Sind.

The seed, which is obtained from Almora in the United Provinces, is sown in light sandy or loamy soil which has been well manured and watered. When the plants are about 20 cm. high they are thinned out and weeded. The remaining plants are pruned to encourage the growth of flowering branches. As soon as the male plants can be identified they are pulled up, since they produce little resin, and shaken over the female ones to ensure fertilisation. Two varieties of plant are met with, the smaller, which produces the best resin, reaching a height of about 1·8 metres. The cutting and preparation of the drug in these villages has recently been described as follows † :—

“ In Ganja making only the flowering tops of the hemp plant are used. They are covered with innumerable glandular hairs exuding a resinous substance. During manufacture, this substance is trodden into the flower heads to impart to the Ganja its narcotic quality.

“ Harvesting of the floral spikes commences in the morning and continues till 5 p.m. The green cuttings, as they are called, are then

* In England the Hindustani word *ganja* is corrupted to *guaza*.

† *The Illustrated Weekly of India*, July 4, 1937, 21.

brought to the manufacturing yard and spread out in long ridges and furrows. The product is left in this condition till the next morning, when the ridges are levelled down and the treading operation begins. This makes the floral shoots into compact sheaves. About a dozen men stand in a line on the edge of the uniformly spread green cuttings and begin treading: they work gradually from the outer edges towards the centre. Frequently the treading is done to the rhythmic beat of the tom-tom, supplemented sometimes by peculiarly shaped wind instruments, to add a touch of gaiety to the work. The beat of the drum, the wailing of the pipes and the weird contortions of some of the treaders all combine to lend a touch of *tamasha* to the scene from which the workers derive as much fun as the onlookers.

"When the cuttings have been completely trodden down they are turned over, allowed to dry for some time, then trodden again. This is repeated four or five times before 5 p.m. They are then collected and arranged in a flat circular heap, called *chakki*, more layers being added to it until the required height of two or three feet is reached. Three or four men stand on the heap and tread in each layer as it is added.

"Heavy stones are then placed on the compact mass. Latent heat is generated within the mass under such pressure and also by the escaping water-vapour and by the gases of chemical changes inside. The manufacturer tests the heat by inserting his hand into the *chakki*. When a certain degree of heat has been reached, the stones are removed, and the *chakki* is broken up into small heaps—which are left in that condition for one night. The following day, the heaps are loosened by hand and the Ganja is spread out in a uniformly thick layer.

"Treading on the *chakki* again follows, and on the fourth day, after one or two more treadings, the Ganja is ready for storage in special sheds. There it is sifted free of dust, stone, seeds and leaves, and then sent to the Ganja depot at Ahmednagar. It is now greenish-brown.

"Insufficient treading results in a semi-dry loosely formed sheaf of Ganja, and carelessness with regard to the temperature of the *chakki* ruins the product. Government derive a revenue of Rs. 30 per seer of Ganja consumed in the Presidency. Constables are placed in the Ganja fields to protect the crop against theft. It is a readily marketable commodity, and the maturing crop acts like a magnet on the inhabitants of neighbouring villages!"

Hemp Products.—Three main types of narcotic product are produced:

1. The short-stemmed pistillata inflorescences which when suitably prepared form *ganja*. The preparation of *flat-* or *Bombay ganja*, the drug used in England, is described above. In Bengal and other parts of India a *round-* or *Bengal-ganja* is prepared by rolling the wilted tops into small masses between the hands (see Fig. 96). *Chur-ganja* or *rora* consists of fragments and powder.

2. *Bhang* (Hindustani) or *Hashish* (Arabic) * consists of

* The Arabic name *hashish* (hemp) is used not only for the plant but also for the crude resin and other preparations made from the plant.

the larger leaves and twigs of both male and female plants. It is widely used in India for smoking, either with or without tobacco and drugs such as opium or datura, or is taken in the form of an electuary made by digestion with melted butter.

3. *Charas* or *churrus* is the crude resin. This is obtained by rubbing the tops between the hands, beating them on cloths or carpets, or by natives wearing leather aprons walking among the growing plants. The resin is scraped off and forms an ingredient of numerous smoking mixtures. Like *bhāng* it is also used with butter.



FIG. 96.—Drying flowers of hemp to form Ganja, Pavedu, North Arcot District, Madras. (From the Imperial Institute Collection.)

In North Africa the product used by addicts is known as *kief* and in South Africa as *dagga*.

Macroscopical Characters.—The flat- or Bombay-guaza of English commerce occurs in agglutinated flattened masses of a dull green or greenish-brown colour. The resin is no longer sticky but hard and brittle; and the odour, which is very marked in the fresh drug, is faint. The drug has a slightly bitter taste. Here and there ovoid hemp seeds may be picked out. Before further examination the drug should be soaked in successive quantities of alcohol to remove the resin, and then softened in water.

The lower digitate leaves of the plant are seldom found in the drug. The thin, longitudinally furrowed stems bear

simple or lobed, stipulate bracts. These subtend the simple bracts enclosing the pistillate flowers. The arrangement thus resembles that of *Humulus* (see Fig. 95, G) except that the outer bracts, which are represented in *Humulus* only by pairs of stipules, have in *Cannabis* a lamina which may be simple or divided into three lobes.* The bract (or bracteole) enclosing each flower is simple. The perigone enveloping the lower part of the ovary and the two reddish-brown stigmas can be seen with a lens.

Microscopical Characters.—The resin is secreted by numerous glandular hairs, 130 to 250 μ long. The head is usually 8-celled and the pedicel multiseriate or unicellular. Abundant conical, curved, unicellular hairs are also found, many having cystoliths of calcium carbonate in their enlarged bases. Cluster crystals of calcium oxalate are abundant, particularly in the bracteoles.

Constituents.—The resin (T. and H. Smith, 1845) is a brown, amorphous semi-solid; soluble in alcohol, ether, and carbon disulphide. It has a powerful narcotic action and is often called "cannabinone," a name given to a product isolated by Merck. By extracting the crude resin, charas, with ether and fractionally distilling the extract a toxic red oil is obtained from which a substance, cannabinol, was isolated (Wood, Easterfield, and co-workers 1896-9). Frenkel (1902) isolated from hemp a thick, strongly-smelling, yellow liquid having powerful narcotic properties, which was also called cannabinol. Fränkel and Czerkis (1907) attribute to cannabinol the formula $C_{21}H_{39}O.OH$, but it appears to be a different substance from the cannabinol examined by Wood and his co-workers.

In addition to the above, the drug contains a small quantity of a laevorotatory, volatile oil containing terpenes, and a sesquiterpene (cannibene); also the alkaloid, choline, and calcium carbonate. It yields about 15 per cent. of ash and from 10 to 18 per cent. of alcoholic extract.

The somewhat imperfect state of our knowledge of this drug is due to the ease with which it deteriorates. As previously mentioned, it is almost inert at the end of two years under ordinary conditions of storage. Deterioration appears to be due to the action of an oxydase enzyme on cannabinol, which oxidises with the greatest readiness. This view is

* See Wallis, *Practical Pharmacognosy*, Fig. 45.

upheld by an observation of Eckler and Miller * that the drug moistened with alcohol and sealed in a barrel retains its full activity for five years.

Varieties.—In addition to the Indian-grown drug described above, importations have taken place of East African, South African, and U.S.A. (1919) drug.

Uses.—Hemp is used as a sedative and hypnotic. It acts chiefly on the central nervous system, producing at first pleasurable excitement and indifference followed by deep sleep. As no chemical assay of the drug is available preparations are sometimes tested by biological means.

Order SANTALES

The order Santales consists of the families Santalaceæ, Loranthaceæ (mistletoe family), Balanophoraceæ, and Cynomoriaceæ.

Family SANTALACEÆ

The family Santalaceæ consists of 26 genera and about 250 species of hemiparasitic herbs, shrubs, and small trees. The woods of several species of *Santalum* and the oils obtained from them are of commercial importance.

SANTALI LIGNUM

Lignum Santalinum Album ; Sandalwood ; F. *Bois de Santal Blanc*, *Bois de Santal Citrin* ; G. *Weisses oder Gelbes Sandelholz*

Source.—Sandalwood is the heartwood of *Santalum album*, an evergreen tree 8 to 12 metres in height which is widely distributed in India and the Malay Archipelago. Supplies are mainly derived from Southern India, from the provinces of Mysore and Madras, where the trees are systematically cultivated and the cutting controlled. In other parts, where no control has been exercised, the trees have been much reduced in number.

Cultivation and Preparation.—The seeds are sown either in beds or two or three in a hole. In the latter case a *Capsicum* seed is also introduced as this germinates very rapidly, shading

* Eckler and Miller, *J. Amer. Pharm. Assoc.*, 1917, 6, 872.

the sandal seedling and at the same time giving it food, for the sandal is a semi-parasite. Trees which are grown slowly in poor soil develop the most heartwood and are the richest in oil. When sufficiently grown (27 to 30 years), the trees are uprooted and deprived of their bark and sapwood. In Mysore, the principal source of supply, the heartwood is conveyed to Government depots, where it is sawn into billets, graded and weighed. In Mysore it is sold by auction, and large quantities of the oil are prepared from it in the State. Some wood is, however, exported and oil distilled from it in Europe.

Characters.—Sandalwood occurs in hard, heavy billets or in chips of a yellowish or pale reddish colour. It has a strong, characteristic odour and a slightly bitter taste.

The volatile oil is contained in all the elements of the wood, namely, medullary ray cells, vessels, wood fibres, and wood parenchyma. The medullary rays are one or two cells wide. The rather large vessels are usually isolated and possess bordered pits. The fibres are very numerous and have obliquely-pointed ends. The small number of wood-parenchyma cells contain prisms of calcium oxalate.

Constituents.—The only important constituent is the oil, *Oleum Santali*.

OLEUM SANTALI

Oleum Santali, B.P., *Oleum Santali Flavi*; *Oil of Sandalwood*, *East Indian Sandalwood Oil*; F. *Huile Volatile de Santal*; G. *Sandelholzöl*, *Ostindisches Sandelholzöl*

Source.—Sandalwood oil is prepared by distillation from the heartwood of *Santalum album*. The yield varies from 1.5 to 6 per cent.

Constituents.—The oil contains about 90 to 97 per cent. of sesquiterpene alcohols, distinguished for purpose of analysis as "santalol." This consists of α -santalol (b.p. 300–301°) and β -santalol (b.p. 170–171°). The oil also contains small quantities of the sesquiterpenes α - and β -santalene, esters, hydrocarbons (santene and nortricycloeksantalane), ketones (santenone and santalolone), alcohols (teresantalol and santenone alcohol), and aldehydes.

The official oil is required to contain not less than 90 per cent. of alcohols calculated as santalol, $C_{15}H_{24}O$, and not less

than 2 per cent. of esters calculated as santalyl acetate, $C_{17}H_{26}O_2$.

Allied Drugs.—The following oils have been examined and particulars of them may be found in Parry's *Chemistry of Essential Oils*: New Hebrides Oil (*S. album*), Tahiti oil (*S. Freycinetianum*), New Caledonia oil (*S. austro-caledonicum*), Fiji oil (*S. Yasi*), South Australian oil (*S. preissianum*), West Indian oil (*Amyris balsamifera*-Rutaceæ), and East African oil (from a species of *Osyris*-Santalaceæ).

OLEUM SANTALI AUSTRALIENSIS

Oleum Santali Australiensis, B.P. ; Oil of Australian Sandalwood ; West Australian Sandalwood Oil

Source.—Australian sandalwood oil is prepared by distillation and rectification from the wood of *Eucarya spicata* Sprague and Summerhayes, a small tree growing in Western Australia.

History.—From the *Pharmacographia* it appears that there has long been a considerable export of Australian sandalwood to China. It is only within recent years, however, that the oil has found a place in English medicine.

Constituents.—The oil contains sesquiterpene alcohols known as "fusanols." When first distilled the proportion of these present in the oil is said to be less than required by the Pharmacopœia, but the subsequent rectification yields an official oil containing not less than 90 per cent. of free alcohols calculated as $C_{15}H_{24}O$.

Uses.—Both Indian and Australian sandalwood oils are used in perfumery. They are also employed as disinfectants for the urino-genital tract and as expectorants in bronchitis.

Order ARISTOLOCHIALES

The order Aristolochiales includes the Aristolochiaceæ and two families of reduced parasitic forms, the Rafflesiaceæ and the Hydnoraceæ.

Family ARISTOLOCHIACEÆ

A family of about six genera and 200 species, of which about 180 belong to the genus *Aristolochia*. Most of the members are herbs or climbing plants with woody stems. Oil-secreting

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cells are found throughout the family, sometimes forming transverse dots on the leaves. The oils of *Asarum europæum* (European snake-wood), *Asarum canadense* (Canadian snake-root), and *Aristolochia Serpentaria* (Virginian snake-root) have been examined.

SERPENTARIÆ RHIZOMA

Serpentaria. B.P.; *Serpentary Rhizome*, *Texan Snakeroot*; *F. Serpentinaire*; *G. Schlangenwurz*

Source.—Official serpentary consists of the dried rhizome and roots of *Aristolochia reticulata*. This is known in commerce as Texan or Red River serpentary and is collected in the woods of Texas, Louisiana, Arkansas, and Oklahoma.



FIG. 97.—Rhizome and roots of *Aristolochia reticulata* (Newman).

Macroscopical Characters.

—The drug has a yellowish colour when fresh, the colour becoming brown on keeping. It consists of small rhizomes bearing the remains of subaerial stems and numerous wiry roots. The rhizomes are about 1 to 2 cm. in length and 2 to 3 mm. in diameter, while the roots are about 10 cm. in length and from 0.2 to 1.2 mm. in diameter. The official drug contains not more than 10 per cent. of subaerial stems. The capsular fruits and fragments of the coriaceous strongly reticulated leaves (from which the plant

receives its specific name, *reticulata*) are occasionally found. Odour, camphoraceous; taste, camphoraceous and bitter.

Microscopical Characters.—A transverse section of the rhizome shows a starchy, eccentric pith (nearer the upper surface of the rhizome than the lower), wedge-shaped, yellowish vascular bundles separated by wide medullary rays, and a

narrow bark. In the roots the bark is relatively large and the endodermis and exodermis are suberised. They have a small central wood and no pith. The stems possess lignified cells in the cortex and are strongly pubescent when young. The powder shows reticulate vessels and tracheids and numerous starch grains, both simple and compound. Occasional oil cells and non-glandular hairs (from the stem) may also be found. Calcium oxalate is absent except for a few rosettes from the leaves.

Allied Drug.—*Virginian snakeroot*, from *Aristolochia Serpentaria*, was formerly official but its regular importation has now ceased. It closely resembles the Texan drug, but has a smaller rhizome and more wiry roots.

Constituents.—The drug contains volatile oil, bitter principles, and tannin, but appears to require further chemical investigation. Virginian snakeroot yields 1 to 2 per cent. of volatile oil and the Texan drug is said to contain rather more. Many species of *Aristolochia* contain bitter substances. The amorphous "aristolochine" found in *A. reticulata* by Chevallier may be an impure form of the orange-yellow, crystalline alkaloid aristolochine isolated from *A. clematitis* and *A. rotunda* by Pohl (1891) and from *A. argentina* by Hesse (1891-2).

Uses.—Snakeroot was formerly used as a snake-bite remedy but is useless for this purpose. It is now mainly employed as an aromatic bitter. In overdoses it produces violent gastro-intestinal irritation.

Order POLYGONALES

The order Polygonales consists of the single family Polygonaceæ.

Family POLYGONACEÆ

A family of about 32 genera and 700 species, of which 29 species are indigenous to Britain (docks, sorrels, bistort, etc.). *Rheum* (rhubarb), which is of central Asiatic origin, is widely cultivated. Most members are herbs with simple, usually entire, leaves with ocreate stipules. The flowers are small, regular, and hypogynous; usually hermaphrodite and trimerous. The typical arrangement consists of two whorls of perianth segments (usually alike), two whorls of stamens, and a triangular tricarpeillary, superior ovary with a single

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and one erect ovule. Doubling of the outer whorl of stamens occurs in *Rheum* and *Rumex*. The fruit is a one-seeded, usually three-winged nut, e.g. the fruits of *Rumex* species, which are used for dusting on Turkish opium.

RHEI RHIZOMA

Rheum, B.P., *Rhei Radix*; *Rhubarb*, *Rhubarb Rhizome*, Chinese, Turkey, or East Indian *Rhubarb*; F. *Rhubarbe*; G. *Rhabarber*, *Rhabarberwurzel*

Source.—The Pharmacopœia describes rhubarb as “the rhizome of *Rheum palmatum* Linn. and possibly other species of *Rheum*, cultivated in China and Tibet, deprived of most of its bark and dried. It is known in commerce as Shensi, Canton or high-dried rhubarb.”

The genus *Rheum* comprises about 25 species, the systematic study of which is made unusually difficult by the tendency of cultivated plants to form hybrids such as *R. palmatum* × *undulatum* and *R. palmatum* × *Emodi*. Tschirch, who has made a profound study of the drug, divides the palmatum-group into *Rheum palmatum* Linn. var. *α-typicum*, *R. palmatum* var. *β-tanguticum* Maximowicz and *Rheum tanguticum* Tschirch.* Photos of the living plants of these species and also of *R. officinale* Baillon and *R. hybridum* var. *Collinianum* Baillon appear in the *Handbuch der Pharmakognosie*. Tschirch is of the opinion that the “northern” rhubarb obtained from Kukunor † is the product of *Rheum palmatum* var. *tanguticum*, while the “southern” rhubarb from Szetschwan is derived from *R. officinale*. The greater part of good Chinese rhubarb appears, however, to be derived from the former source.

The “northern” rhubarb grown in Kukunor (Tibet) and in the neighbouring Chinese province of Kan-su is sold to merchants from Shen-si, whence it is conveyed down the Han-kiang ‡ to Hankow and the Yang-tse-kiang to Shanghai. Some rhubarb is also produced in Shen-si but whether this is

* According to Himmelbaur, Y. B. Pharm., 1929, p. 135, *Rheum tanguticum* Tschirch is a hybrid.

† For a map of the rhubarb-growing districts of China see Tschirch, *Handbuch der Pharmakognosie*, Band II, A. 2, p. 1366.

‡ Kiang = river

derived from the same type of plant as that found in Kukunor is not known. The "southern" rhubarb grown in the Chinese provinces of Szetschwan and Hupei, *i.e.* on the highlands flanking the north bank of the Yang-tse-kiang, passes to places on the river such as Tschung-king (Chung-king) and thence by boat to Hankow and Shanghai.

History.—Rhubarb is mentioned in a Chinese herbal dated about 2700 B.C. Trading caravans are known to have passed from Shensi westward to Bokhara as early as 114 B.C., whence the drug might have reached Europe either by way of the Black Sea or down the Indus to the ancient port of Barbarike. The drug known to Dioscorides and Pliny as *Rha* (the ancient name for the Volga) is generally regarded as a species of *Rheum*, possibly *R. rhaponticum*, grown east of the Black Sea. Scribonius Largus and Celsus in the first century A.D. call the drug *Radix pontica* or *Rha ponticum* (Pontus Euxinus being the ancient name for the Black Sea). It has therefore been suggested that rhubarb imported *via* the Black Sea would be called *rha-ponticum* and that coming *via* Barbarike would be known as *rha-barbarum*, whence our names rhapontic and rhubarb.

The Arabs were aware that the drug sold as Turkey or Persian rhubarb, which came from the East *via* Persia to the Levant ports (eleventh and twelfth centuries), was of Chinese origin and preferred it to the pontic variety. Marco Polo (1250-1323), the celebrated Venetian traveller who lived in China for about thirteen years, mentions the abundance of rhubarb in the ancient kingdom of Tangut (which corresponds roughly to the modern province of Kan-su).

The Levant rhubarb gradually disappeared from trade, and in 1640 the drug principally used in England was shipped direct from China or by way of India, and was known as Chinese, Canton* or East Indian rhubarb. The name "Turkey rhubarb" was, however, applied in England (but not on the Continent) to the drug imported through Russia. From 1653 Chinese rhubarb was imported into Russia by a more northerly route than hitherto, passing through Urga on the north of the Gobi desert and through Siberia to Moscow. The Russian Government, 1687-1762, held a virtual monopoly of the trade and by rejecting all rhubarb which was not of the highest quality the "Moscovy" drug gained a deservedly

* Prior to 1842 Canton was the only Chinese port open to European trade.

high reputation. Canton, however, offered an easier outlet for the drug, and the freeing of the other Chinese ports in 1860 rapidly led to the abandonment of the Russian route and, incidentally, to the export of less carefully prepared drug.

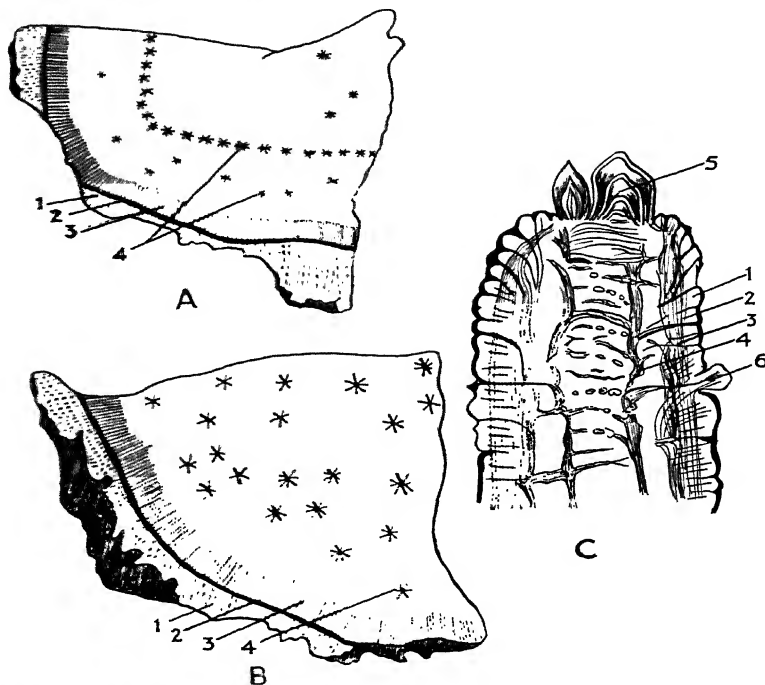


FIG. 98.—Rhubarb. A, diagrammatic transverse section of rhizome of *palmatum*-type; B, the same of *officinale*-type; C, longitudinal section of a young rhizome of *R. palmatum* var. *β-tanguticum*. 1, phloem; 2, cambium; 3, radiate wood; 4, star-spot; 5, apical bud; 6, lateral bud. (A and B after photomicrographs by Tschirch, C after Tschirch-Oesterle, *Atlas*.)

Collection and Preparation.—Chinese rhubarb is mainly collected in the mountains at a height of about 3,000 to 4,000 metres, that grown at a lower level being less esteemed.*

* Perrot and Goris have shown that rhubarb grown in the Pyrenees is of similar quality to the Chinese drug, while most European rhubarb is much inferior. Bavaria, another mountainous country, is said to grow rhubarb of excellent quality.

The rhizomes are dug in the autumn or spring when about 6 to 10 years old. After cleaning, the crown and smaller branches are cut off, the rhizome is decorticated and is then cut into convenient-sized pieces for drying. Some pieces are sliced longitudinally, yielding the "flats" of commerce, while those which are only cut transversely are called "rounds." The drug of English commerce may be divided into four grades, namely, Shensi (flats and rounds), Canton (flats and rounds), Se-Tschouen (flats), and "Common Rounds." The last two grades are together known as "High-dried."

Shensi and Canton rhubarbs are dried without the aid of artificial heat, holes being frequently drilled in the pieces by means of which they are threaded on cords and suspended in the shade of trees or in huts. In some districts, e.g. Se-Tschouen, the climate is not favourable for open-air drying and the drug is dried artificially over brush-wood fires or on heated stones. The drug is imported in zinc-lined wooden cases.

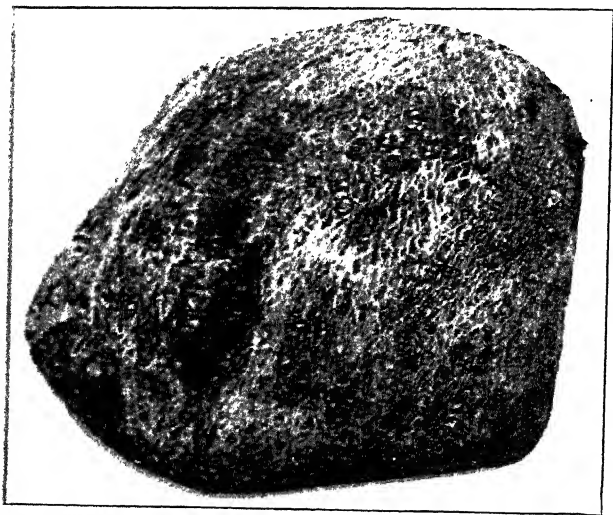
Rhubarb is somewhat liable to insect attack and the pieces are sometimes decayed internally. Buyers pay particular attention to the fracture and state of the interior of the drug, preferring that with a good pink fracture (see Fig. 10). Before powdering, each piece should be split open and any dark or decayed portions removed with a chisel or file.

Characters.—The rhizomes of *Rheum palmatum* and *R. officinale* are essentially similar in structure. Fig. 98, C, shows a longitudinal section of a two-year-old rhizome of the *palmatum*-type. As mentioned above, the crown and most of the bark have been removed in the commercial drug. The cambium produces phloem on its outer side and normal radiate wood on its inner side. In addition, abnormal vascular bundles known as "star-spots" are produced at an early stage in the pith.* These anastomose with one another and with the leaf-trace bundles. According to Tschirch, rhizomes of the

* Solereder's *Systematic Anatomy of the Dicotyledons* (English translation), p. 673. "In a young branch of the rhizome the pith is traversed by a complete network of anastomosing strands of soft bast, which are arranged in transverse zones, following closely upon one another and corresponding to the nodes; these strands unite the leaf-traces, and are also connected with one another by bundles, which traverse the internodes either in a vertical or oblique direction, and mostly run in the neighbourhood of the xylem-ring. Around each of these strands of soft bast a cambial ring, developed at an early stage, produces rays of soft bast on its inner, and rays of wood with abundant parenchyma on its outer side, whilst between the rays of wood and bast it gives rise to medullary-ray-tissue which becomes filled with red colouring-matter. Besides occurring in *R. officinale*, they are found in *R. Emodi*, *R. raphanicum*, and *R. palmatum*, but they are not present in *R. rugosum* and other species."

i-type are distinguished by the relatively small size of the star-spots (average diameter 2.5 mm.) and the fact that they form a continuous ring, while *R. officinale* has larger star-spots (average diameter 4.1 mm.) which are more irregularly distributed (see Fig. 68, A and B).

Bearing the above facts in mind, the Pharmacopœia should be consulted and the outer surface and transverse section of the drug examined.



69.—Chinese rhubarb—Shensi round. The reticulations have been rendered more distinct by washing off the adherent powder (Newman).

(a) **Surface.**—The firm texture, non-shrunk appearance and reticulations of the outer surface help to distinguish the Chinese drug from European rhubarbs. The reddish-brown, fusiform or lozenge-shaped markings on the outer surface are the medullary rays, and the whiteness of their background is due to starch and calcium oxalate contained in the phloem-parenchyma. The reticulate effect is best seen in rhizomes of the *palmatum*-type, the medullary rays of which are narrow and only about 6 cells deep. In the English *officinale* drug such reticulations are rare since the medullary rays are about

3 to 6 cells wide and from 40 to 200 cells deep, and the appearance is one of somewhat elongated, parallel, red and white lines. Similar parallel lines are found on Chinese high-dried rhubarb and on English rhapontic rhizomes (but not as a rule on Continental "rhapontic," which is not of the same botanical origin as English "rhapontic").

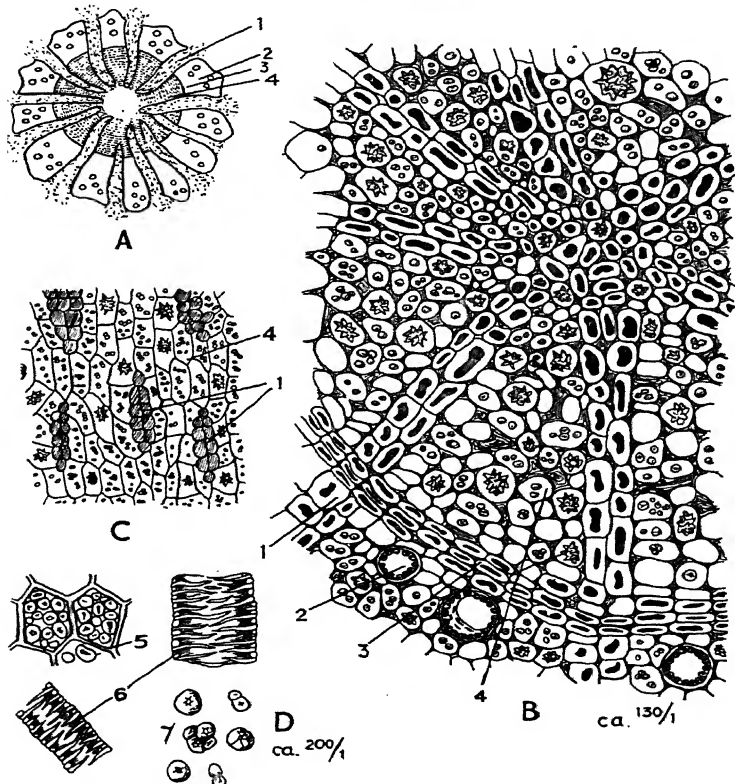


FIG. 100.—Chinese rhubarb. A, diagram of a star-spot; B, portion of same; C, medullary rays as seen in tangential longitudinal section, *i.e.* on outer surface of drug; D, elements of powder. 1, medullary ray; 2, xylem with few vessels and abundant parenchyma; 3, cambium; 4, phloem containing starch and calcium oxalate; 5, starch-containing cells of pith; 6, fragments of vessels; 7, starch. (A and C after Planchon, B after Möller, D after Greenish and Collin.)

Any small reddish-brown points on the surface are leaf-trace bundles, which have a star-spot structure. If the drug has been very deeply peeled the outer surface will consist of the normal or even the abnormal wood. In the flats the inner surface shows star-spots, and the union of these with one another and with the leaf-traces may be seen. The best rhubarb is usually covered with powder produced by filing



FIG. 101.—Chinese rhubarb—Canton round (Newman).

the pieces after drying, and the removal of this by rapid washing makes the surface reticulations much clearer.

(b) **Transverse Section.**—In transverse section the cambium appears as a dark line with a certain amount of phloem on its outer side. Here and there it is interrupted by deep peeling and the radiate wood may also be partly removed, especially in the severely cut, high-dried variety. The differences in

size and arrangement of the star-spots in the *palmatum*- and *officinale*-types may be seen in Fig. 98.

(c) Powder.—Powdered rhubarb, when derived from rhizomes having a good pink fracture, is of a bright yellow colour. It has a characteristic odour and a bitter, slightly astringent taste.

Rhubarb may be identified under the microscope by the abundant, very large calcium oxalate rosettes; the simple and compound starch grains; the reticulate vessels and other

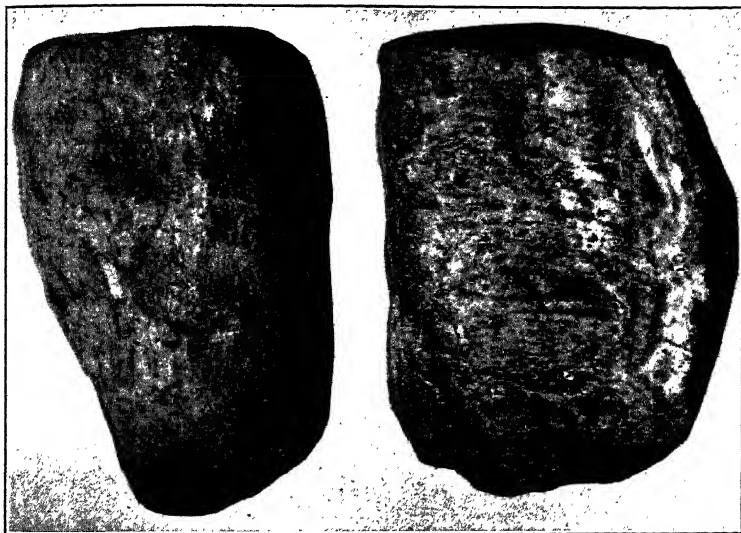


FIG. 102.—English rhubarb—*Rheum officinale* (Newman.)

wood elements, which give no reaction for lignin; and by the yellow-coloured masses of the medullary ray cells, which are insoluble in water and give a pink or red colour with alkalis.* See also, p. 109.

Varieties.—The names of the following commercial varieties have no precise geographical significance:—

Shensi.—This is the best variety and corresponds most closely with the official description. Its appearance has

* According to Berthier (1899) the anthraquinone derivatives are localised in the cells of the medullary rays and wood parenchyma.

usually been improved by filing, which leaves a yellow coat of powder. The drug is very compact, unshrunk, and almost free from empyreumatic odour. When broken with a mallet or axe (cutting or sawing produces powder) the transverse section is uniformly pink and of the *palmatum*-type. It yields a bright orange-yellow powder.

Canton rhubarb, although an important variety, appears to be imported to a lesser extent than was formerly the case. It usually lacks the bright yellow coat of the Shensi and the surface reticulations are less marked. Internally it is pinkish



FIG. 103.—Chinese rhapontic rhubarb (Newman).

and granular, the star-spots as a rule being indistinct. The odour is more empyreumatic than the Shensi.

High-dried.—This term includes Se-Tschouen flats and “common rounds,” the former usually being of the better quality. These are extremely hard and difficult to break, tending to fracture obliquely whilst the Shensi and Canton break transversely. The transverse section closely resembles that of the Shensi, but the general appearance and strong, empyreumatic odour makes this variety inferior to the Canton.

Allied Drugs.—Attempts to produce medicinal rhubarb have been repeatedly made in England and on the Continent,

but the results obtained have not been sufficiently successful to lessen appreciably the demand for the Asiatic drug. English rhapontic rhubarb has been grown near Banbury since 1777 and *Rheum officinale* in the same neighbourhood since 1873. *Rheum palmatum* was grown in Somerset, Worsshire, and Middlesex in the eighteenth century. In considering the structure of English and Continental rhubarbs the tendency of the plants to form hybrids must not be neglected.

English officinale rhubarb is spongy in texture and inferior to the Chinese drug. The outer surface is wrinkled and bears conspicuous parallel, red and white lines. The star-spots are of the large and scattered *officinale*-type.

English rhapontic rhubarb consists of rhizomes and roots, which are usually sold separately. The surface is deeply wrinkled. The rhizomes possess scattered star-spots but the roots are entirely radiate in section. Whereas good Chinese rhubarb is uniformly pink internally, this drug is partly pink and partly of the bright orange colour of a fresh dock root.

Chinese rhapontic rhubarb is usually smaller and darker than the above. The exterior is furrowed and often bears cork. The pieces tend to be hollow or cracked in the centre. The section consists mainly of pink radiate wood, which forms well-marked concentric rings.

Constituents.—Rhubarb contains two types of compounds, one exerting a purgative and the other an astringent effect. These are sometimes called the rheoanthraglycosides (anthraquinone derivatives) and rheotannoglycosides (astringent principles) respectively.

1. **Anthraquinone Derivatives.**—Experiments made on fresh rhubarb by Wasicky and Heinz indicate that no free anthraquinones are present in the fresh drug; but anthraquinone glycosides are found, except in the winter when they are replaced by anthranol glycosides. The above seasonal change is of interest, since if collection of the Chinese drug is interrupted by early snow, collection appears to be resumed in the early spring.

Rhubarb has been repeatedly examined and the following anthraquinone derivatives isolated:—

Chrysophanol or *chrysophanic acid*, $\text{CH}_3\cdot\text{C}_{14}\text{H}_5\text{O}_2(\text{OH})_2$ (Schlossberger and Döpping, 1844), and its glucoside (Gilson, 1898, and Hunkel, 1900).

Aloe-emodin, $\text{CH}_2(\text{OH})\cdot\text{C}_{14}\text{H}_5\text{O}_2(\text{OH})_2$, the primary alcohol corresponding to chrysophanol (Hesse, 1894).

Rhein, $\text{COOH.C}_{14}\text{H}_5\text{O}_2(\text{OH})_2$, the acid corresponding to aloe-emodin.

Emodin (*Frangula-emodin* or *rheum-emodin*), $\text{CH}_3.\text{C}_{14}\text{H}_4\text{O}_2(\text{OH})_3$ (De la Rue and Müller, 1857).

Emodin monomethylether, $\text{CH}_3.\text{C}_{14}\text{H}_4\text{O}_2(\text{OH})_2.\text{O}.\text{CH}_3$, and its glucoside (Gilson, 1905).

About 2 to 4.5 per cent. of these compounds is probably present but the methods of estimation give only approximate results. It has been said that of these compounds only chrysophanol and aloe-emodin are laxative, and Kroeber (1923) considers they contribute little to the purgative action of the drug. Tschirch and Schmitz (1928), however, strongly deny the statements which have been periodically made to the effect that the anthraquinone derivatives are relatively inert, and point out that the physical state of these substances appears to influence their physiological action.

Tutin and Clewer (1911) consider the chief laxative constituent to be a non-glycosidal resinous mixture yielding gallic acid, cinnamic acid, and a number of anthraquinone derivatives on hydrolysis. Casparis and Goldin (1923), on the other hand, attribute part of the laxative action to reduction products of the anthraquinones.

2. Astringent Principles.—The chief astringent principles, according to Gilson, are glucogallin, free gallic acid, and catechin. Glucogallin gives glucose and gallic acid on hydrolysis.

Rhubarb also contains rheinolic acid, a phytosterol (verosterol), starch, sugars, fat, pectin, and calcium oxalate (about 7 per cent.). Chinese rhubarb yields about 7 to 13 per cent. of ash and European 1.3 to 6 per cent. The acid-insoluble ash should not exceed 1 per cent. In the absence of a satis-

method of assay, the amount of alcohol (45 per cent.)-soluble extractive is an indication of purity (B.P. not less than 35 per cent.).

Constituents of Rhapontic Rhubarb.—Rhapontic rhubarb appears to contain no emodin, aloe-emodin, or rhein. It contains a crystalline glycoside, rhaponticin, which gradually separates on standing from an ethereal extract of the drug. Tests based on this fact are not sufficiently delicate to show the presence of less than about 25 per cent. of rhapontic rhubarb in a mixture with Chinese. Pure rhapontic can be distinguished from Chinese by examination in filtered ultra-violet light, the rhapontic giving a violet colour and the

Chinese a velvety brown. Here, again, the technique requires improvement to make the test of more practical value in the detection of mixtures. See, however, Fig. 231. The technique now described in the Pharmacopœia is said to detect rhubarbs containing 5 per cent. or more of the rhapontic drug.*

Tests.—Chinese rhubarb gives the usual tests for anthraquinone derivatives, gallic acid and catechin. In the author's experience the commercial drug does not respond to the borax fluorescence test and the selenious acid-sulphuric acid test, which indicate the presence of anthranols in aloes and araroba.

Uses.—Rhubarb is used as a bitter stomachic and in the treatment of diarrhœa, purgation being followed by an astringent effect. The drug is suitable as an occasional aperient, but not for the treatment of chronic constipation.

Order PIPERALES

The order includes the Piperaceæ and two small families of little importance.

Family PIPERACEÆ

A family of 9 genera and about 1,300 species, of which over 700 species belong to the genus *Piper*. The species of *Piper* are almost all shrubs or lianes with swollen nodes and fleshy spikes of flowers. The leaves contain oil cells, e.g. *Piper angustifolium* (matipo) and *Piper Belle* (betel). Those of the latter species were formerly official and are largely used in the East with areca and lime as a masticatory. The one-celled ovary has a single, basal ovule. The seeds contain endosperm and abundant perisperm.

PIPERIS NIGRI FRUCTUS

Piper Nigrum; Black Pepper; F. Poivre Noir;
G. Schwarzer Pfeffer

Source.—Black pepper consists of the dried, unripe fruits of *Piper nigrum*, a perennial climbing plant cultivated in the Malay Archipelago, Southern India, and the West Indies. Large quantities are obtained from Sumatra and Penang and from the Malabar coast (Tellicherry).

History.—Pepper was known to Theophrastus and other ancient writers. It was the most important spice used in the

* Wallis and Withell, *Y.B. Pharm.*, 1934, 574-580. For the detection of rhapontic rhubarb in galenicals, see Crews, *Y.B. Pharm.*, 1936, 434-444.

Middle Ages and was imported into England about A.D. 1000. The high cost of pepper and other Eastern spices was a big inducement to the Portuguese to find a sea-route to India, and competition for the spice trade has played a large part in the colonial expansions of European nations.

Collection and Preparation.—The pepper vines are grown on poles or trees. The inflorescence is a spike of about 20 to 30 sessile flowers, which develop into sessile fruits. The latter

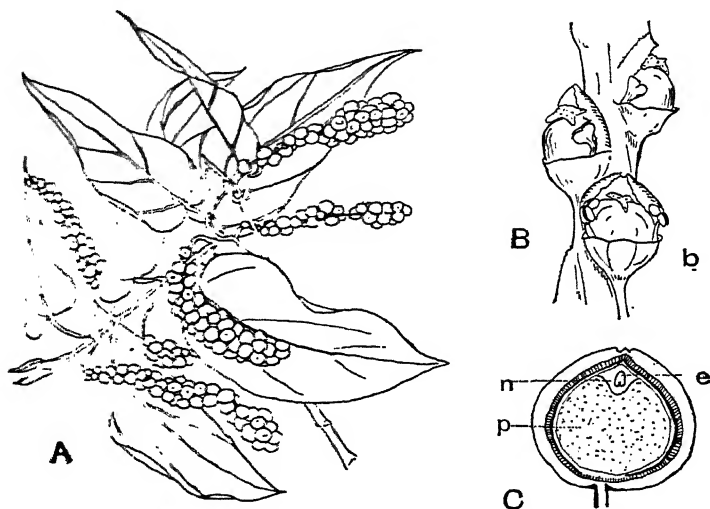


FIG. 104.—*Piper nigrum*. A, shoot bearing spikes of fruits, $\times \frac{1}{2}$; B, small flower-spike showing three flowers, $\times 4$; b, bract; C, fruit in longitudinal section $\times 4$; e, embryo; n, endosperm; p, perisperm. (From Rendle's *Classification of Flowering Plants*.)

are picked when the lower fruits of the spike turn red. They are then removed from the axis and dried, either in the open air or by artificial heat. The fire-dried spice, which has a somewhat smoky odour, is most esteemed but the ground spice is usually a blend of different varieties.

White pepper, which is largely used in the East, is also obtained from *Piper nigrum*, but the fruits are allowed to become more completely ripe. After storing them for some days or soaking them in water, the outer part of the pericarp is removed by rubbing and washing, and the fruits are dried.

Macroscopical Characters.—The fruits are almost globular and from 3·5 to 6 mm. in diameter. The surface is dark brown or greyish-black and strongly reticulated. The apex shows the remains of the sessile stigmas and a basal scar indicates the point of attachment to the axis. Pepper has an aromatic odour and pungent taste.

Microscopical Characters.—A longitudinal section shows that the pericarp consists of the following layers :—(a) epidermis, (b) stone-cell layer, (c) parenchymatous region containing isolated oil cells and fibrovascular bundles and on its inner side a definite band of oil cells, (d) a single layer of cells with strongly thickened inner tangential walls, (e) a double row of brown pigment cells, the inner ones darker than the outer. Within the pericarp, and completely filling the interior, lies the seed. This consists of a small embryo, embedded in endosperm, situated near the apex of the fruit, and a large amount of perisperm in which there is frequently a central cavity. Oil cells are distributed throughout the perisperm.

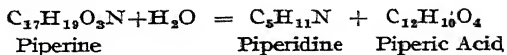
In white pepper, owing to the removal of the outer part of the pericarp, the vascular bundles, which are about sixteen in number, run on the outside of the fruit from base to apex.

Allied Drugs.—As mentioned previously, the number of *Piper* species is very large and a description of all the fruits resembling pepper is outside the scope of this book.

Long Pepper is the dried unripe fruit of *Piper officinarum*, a Javanese species. The spice consists of whole spikes of small fruits forming a structure about 4 cm. long and 6 mm. in diameter. Individual fruits show a similar structure to black pepper.

Constituents.—Pepper contains from 1 to 2·5 per cent. of volatile oil, from 5 to 9 per cent. of the crystalline alkaloid piperine, and a resin (chavicin). The aroma of the spice is due to the volatile oil, which consists largely of terpenes (phellandrene and dipentene), while the pungency is ascribed to piperine and the resin.

Piperine, $C_{17}H_{19}O_3N$, was isolated by Oersted in 1819. It has since been found in *Piper officinarum* (1 to 2 per cent.) and in Ashantee pepper, the fruits of *Piper Chusii*. On heating with alcoholic potash piperine is hydrolysed with formation of the base piperidine (hexahydropyridine) and the potassium salt of piperic acid :



The resin is more resistant to hydrolysis with alcoholic potash. It has been shown (Off, Eichler, Lädemann, and Heimann, 1922) to be a compound of piperidine and chavicol acid.

Black pepper should yield not more than 6.5 per cent. of ash and white pepper not more than 3 per cent. Ether extracts about 7.5 to 10 per cent. from black and about 6 to 9 per cent. from white pepper.

Uses.—Pepper is now little used in medicine but large quantities are used as a condiment.

CUBEBAE FRUCTUS

Cubeba ; *Cubebs*, *Tailed Pepper* ; *F. Cubèbe*, *Poivre à Queue* ;
G. Kubeben

Source.—Cubebs are the dried, full-grown fruits of *Piper Cubeba*, a native of Java, Borneo, and Sumatra. The fruits are collected while green and dried in the sun. They were used in Europe as a spice as early as the eleventh century.

Characters.—The spikes of cubebs bear more fruits than those of pepper and although the fruits resemble those of pepper when young, they become falsely stalked as they mature owing to an abnormal development of the base of the pericarp. A similar pseudo-stalk is found in other *Piper* species which occur as cubeb adulterants, e.g. *Piper Clusii*, *P. ribesoides*, and *P. Lowong*.

The upper part of the cubeb fruit is globular, 3 to 6 mm. in diameter, and covered with a greyish-brown, reticulated pericarp, which is prolonged at the base into a straight stalk. The latter seldom exceeds 7 mm. in length, while many of the possible adulterants have longer or shorter stalks.

The internal structure of cubebs resembles that of black pepper, but microscopical examination of the pericarp discloses numerous differences in detail. Sections of both cubebs and black pepper give a red colour when treated with concentrated sulphuric acid, but this test taken in conjunction with the microscopic structures distinguishes these drugs from their adulterants, many of which have been examined by Hartwich (1898).*

Constituents.—Cubebs yield 10 to 18 per cent. of volatile oil containing terpenes and sesquiterpenes, a crystalline

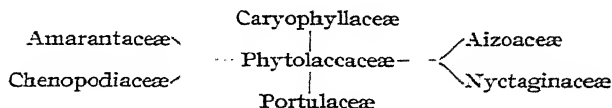
* A summary of Hartwich's results will be found in the *U.S. Dispensatory*.

inodorous substance cubebin, a white amorphous substance cubebic acid (1 per cent.), and amorphous resin (3 per cent.). Cubebin and cubebic acid give a red colour with sulphuric acid. Good cubebs yield about 6 per cent. of ash and about 22 per cent. of ethereal extract.

Uses.—The drug has been employed in gonorrhœa and in chronic bronchitis. The oil has, however, been deleted from the Pharmacopœia and is now little used.

Order CENTROSPERMÆ

In this order, which consists of seven families, is seen a passage from the monochlamydeous type of flower (*e.g.* families Phytolaccaceæ and Chenopodiaceæ) to the dichlamydeous type of flower (*e.g.* Caryophyllaceæ). The families within the order and their relationship to one another may be illustrated thus :



Plants of medicinal interest, other than those of the Chenopodiaceæ, are : *Saponaria officinalis* (Caryophyllaceæ), which is rich in saponins and is widely used on the Continent, and *Phytolacca decandra* (Phytolaccaceæ), the leaves and roots of which are sometimes found in belladonna, while its purple berries are used for colouring.

Family CHENOPODIACEÆ

A family consisting of 75 genera and 500 species ; mostly herbs or shrubs with alternate, exstipulate leaves. Floral formula typically P₅, A₅, G(2-3). The ovary is unilocular and one-seeded ; fruit a nut. Of economic importance are the beet, *Beta vulgaris* and spinach, *Spinacia oleracea*.

The structure of the axis is often abnormal. This is well seen in the beet, where successive short-lived cambia arise in the inner part of the cortex, producing concentric zones of vascular bundles and conjunctive tissue (compare with that of *Chenopodium* and with *Phytolacca*).

CHENOPODII AMBROSIOIDIS HERBA

Chenopodium; American wormseed, Mexican Tea; F. *Ansérine Vermifuge*; G. *Amerikanisches Wurmsamen*

Source.—The official oil of chenopodium is obtained by steam distillation from the fresh, flowering and fruiting plants, excluding roots, of *Chenopodium ambrosioides* Linn. var. *anthelminticum* Gray. The plant is common in the Eastern U.S.A. and is largely cultivated in Maryland.

Characters.—The plant is about 30 to 60 cm. in height. The lower leaves are 5 to 10 cm. long and the upper ones about 1 to 2 cm. long. The flowers and fruits are both small, the latter, which alone form *Chenopodium* B.P.C., are about 0.5 to 0.9 mm. in diameter. The oil is secreted by glandular hairs which are found on the leaves, flowers, and fruits. The leaves, sometimes known as Mexican tea, have been found in samples of belladonna, and although both contain sandy crystals of calcium oxalate, the hairs of the two plants are quite different. The plant has a strong, characteristic odour.

Constituents.—*Chenopodium* herb contains about 0.4 to 1 per cent. of volatile oil, and the fruits about 1 to 4 per cent. This contains 60 to 77 per cent. by volume of ascaridole, $C_{10}H_{16}O_2$ (B.P. not less than 65 per cent. w/w). According to Henry and Paget (1921), the oil also contains about 5 per cent. of the corresponding glycol (see below) and 30 to 40 per cent. of a mixture of hydrocarbons (cymene, α -terpinene, etc.).

Ascaridole is liable to explode on heating at ordinary pressure or on treatment with certain acids. It gradually decomposes on boiling with water, and distillation must therefore be carried out as rapidly as possible. After decomposing ascaridole by heat or by treatment with ferrous sulphate Nelson (1920) isolated from the reaction mixture two glycols of the formula $C_{10}H_{18}O_3$ and an erythrite, $C_{10}H_{20}O_4$.

Uses.—Oil of chenopodium is a valuable anthelmintic but must be used with considerable care. It has also been employed in the treatment of amoebic dysentery.

CHAPTER XX

Phylum **ANGIOSPERMÆ** ; Subphylum **DICOTYLEDONS**

Grade B. **Dialypetalæ**

Order **RANALES**

THIS large order * may be conveniently divided into two groups of families :—

A. Woody plants, generally possessing oil cells in the parenchyma, *e.g.* Magnoliaceæ, Myristicaceæ, and Lauraceæ.

B. Herbaceous plants, without oil cells, *e.g.* Ranunculaceæ, Berberidaceæ, and Menispermaceæ.

The flowers are regular (*e.g.* *Illicium* or *Ranunculus*) or zygomorphic (*e.g.* *Aconitum*), and usually hypogynous. Perianth generally petaloid or divided into calyx and corolla. Stamens numerous ; carpels numerous and free (*e.g.* *Illicium*) or solitary (*e.g.* *Myristica*).

Family :

A family of 9 genera and about 100 species. Species of *Magnolia* and the Tulip-tree, *Liriodendron tulipifera*, are widely cultivated. Of medicinal interest are the fruits of various species of *Illicium*, and *Drimys Winteri*, which yields the rare drug Winter's bark.

ANISI STELLATI FRUCTUS

Star-Anise Fruits ; F. Anis Étoilé, Badiane de Chine ;
G. Sternanis

Source.—The fruits of the Chinese star-anise, *Illicium verum* Hooker filius (*I. anisatum* Loureiro not *I. anisatum* Linn. and Gaertner), yield part of the official oil of anise, the remainder

* The arrangement here adopted is that of Rendle's *Classification of Flowering Plants*. Hutchinson, in *The Families of Flowering Plants*, divides the group into five orders, namely, Magnoliales, Anonales, Laurales, Ranales, and Berberidales.

being obtained from the fruits of *Pimpinella Anisum* (Umbelliferae). The star-anise is an evergreen tree about 4 to 5 m. in height indigenous to the S. and S.W. provinces of China. The fruits are collected by means of bamboo ladders from both wild and cultivated trees growing in the Chinese provinces of Kwangsi, Kwangtung, and Yun-nan; the island of Hai-nan; and in the N.W. of French Indo-China (Tong-king). Most of the oil is distilled locally, particularly in the neighbourhood of Lang-son, by heating the fruits with water in primitive iron stills. The oil is exported from Hai-fong and Hong-Kong in leaden canisters (Fig. 105), which are packed in fours in wooden cases.

Characters.—Seven species of *Illicium* are known, five in Eastern Asia and two in Florida. The fruits of *I. verum* consist of eight (rarely seven or nine) one-seeded foliicles (distinction from *I. Griffithii* of India and *I. Cambodiana* of Tong-king, both of which have ten to thirteen carpels). Each foliicle is about 12 to 17 mm. in length. The pericarp is reddish-brown, woody, and only slightly wrinkled. Each carpel has, as a rule, partly dehiscent to expose the seed. The latter has a brittle, shining testa and an oily kernel. The beak of each carpel is not turned upwards and the fruit stalk, which is about 3 cm. long, is curved (distinction from *I. religiosum*). The oil, which is present in both seed and pericarp, gives the drug an aromatic odour and spicy taste.

Allied Drug.—*Bastard star-anise* or *shikimi* fruits occur in Eastern commerce and are occasionally exported. They are derived from *I. religiosum*, a species cultivated near the Buddhist temples in Japan and also on the mainland. The carpels are equal in number to those of *I. verum* but are smaller, much wrinkled, and have a curved-up apex. The stalk is shorter than the genuine, and straight. It contains sclerenchymatous cells which are about one-fifth of the length of those found in the stalk of *I. verum*.

These Japanese fruits are poisonous since they contain an amorphous toxic substance sikimitoxin, and a crystalline toxic substance sikimin. They have a balsamic odour owing to the presence of an oil containing safrole.

Constituents.—The genuine fruits yield about 2.5 to 5 per cent. of volatile oil (Oleum Anisi B.P.). This contains about 80 to 90 per cent. of anethole (a colourless crystalline solid, m.p. 21°), *d*-pinene, *l*-phellandrene, and probably traces of safrole. The latter compounds have not been shown to be

present in the oil of *Pimpinella Anisum*, but for all ordinary purposes the oils are indistinguishable. The oil is liable to atmospheric oxidation and both anisic aldehyde and anisic acid are normally present. This change is said to diminish the tendency of the oil to solidify, which it normally does on

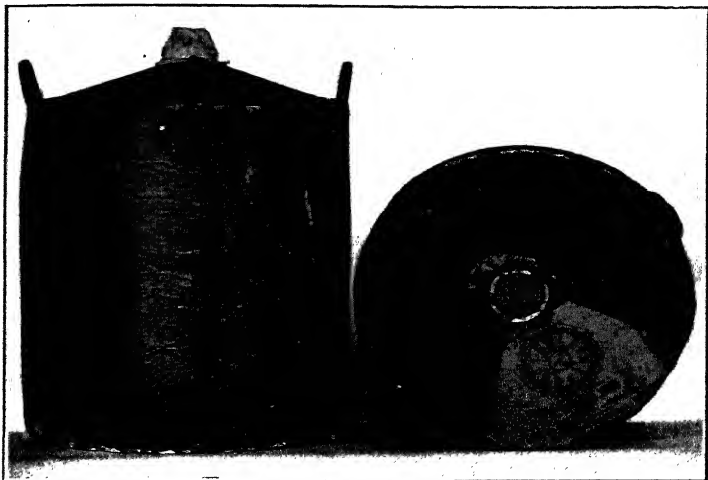


FIG. 105.—Lead containers of star anise oil (left), and cassia oil (right) (Sutcliffe).

cooling to about 15° . As previously mentioned, the oil is imported in lead containers, and it will be noted that the Pharmacopœia gives a limit test for this metal.

Uses.—Oil of anise is used as a flavouring agent and carminative.

Family MYRISTICACEÆ

A family of 11 genera and about 250 species. The flowers are dioecious and consist of an inconspicuous three-lobed perianth with three to eighteen monadelphous stamens or a solitary carpel containing a basal, anatropous ovule. The fruit is a fleshy drupe, which splits along both dorsal and ventral sutures. The single seed is more or less completely enveloped in a lobed aril. The structure of the seed is described below. Secretory

cells commonly occur in the mesophyll of the leaves, in the axis and in the kernels of the seeds. Many members possess tannin sacs and characteristic, often stellate, clothing hairs.

MYRISTICA

*Myristica B.P., Semen Myristica, Nux Moschata ; Nutmeg ;
F. Noix de Muscade ; G. Muskatnüsse*

Source.—Nutmegs are the dried kernels of the seeds of *Myristica fragrans*, an evergreen tree about 10 to 20 m. in height indigenous to the Molucca Islands. The plant is now widely cultivated not only in the East Indies and Malay States (Molucca Islands, Sumatra, Java, Singapore, and Penang), but also in Ceylon and the West Indies (Grenada). Grenada now supplies about half of the nutmegs used in the U.S.A.

History.—Nutmegs and mace appear to have been first introduced into the Levant by the Arabs in the middle of the twelfth century and by the end of that century were found in Northern Europe. The native country of the nutmeg (the Molucca or Spice Islands) was known to Arabian writers of the thirteenth century, and the Banda Islands, a group of the Moluccas where the plant is very abundant, were discovered by the Portuguese in 1512. The Portuguese, after holding the spice trade for about a century, lost it to the Dutch, who maintained a complete monopoly by destroying the trees in neighbouring islands and preventing the export of living seeds. The ordinary drying process destroys the vitality of the seeds but they were also soaked in milk of lime for many weeks and were seldom sold until they were several years old. The Spice Islands were occupied by the English for a few years (1796-1802) during which period the opportunity was taken to start cultivation in Penang and Sumatra. Until the trees so planted reached maturity the effect of the Dutch restriction was still felt, and in 1806 the import price of mace in London was as high as 90s. per lb.

Cultivation, Collection, and Preparation.—Nutmeg trees are grown from fresh seed sown in the shell. They are usually unisexual, in which case most of the male plants are eliminated from the plantations, but sometimes both male and female flowers are produced on the same tree. They bear fruit from

their eighth or ninth year and continue to fruit well for about twenty to thirty years. The fruit consists of a peach-like, fleshy drupe which splits when ripe, exposing the seed with its lobed, red arillus.

The plant fruits almost continuously and two or three crops are collected annually. In the East the fruits are collected by hand or by means of a hooked stick, but in Grenada the fruits are allowed to fall to the ground. The orange-yellow pericarp (Fig. 108), which is about half an inch thick, is usually removed on the spot. Later the arillus is picked off and constitutes, when dried, mace. The nutmegs are dried in the shells, the procedure differing according to local conditions but usually taking about three to six weeks. In Malaya sun-drying is used to some extent, but the seeds require adequate cover at night or in wet weather. Large quantities are dried in ovens and in brick buildings. In the latter the seeds are placed on trays over low charcoal fires, being turned and gradually moved nearer to the fires during the process. When drying is completed the kernel rattles within the brittle testa which constitutes about one-quarter of the weight of the seed. The testa is cracked by means of a wooden truncheon, mallet (Fig. 106) or special machine, and the nutmeg extracted. Machines are, however, liable to cause bruises, and cracking by hand is preferable. The liming of nutmegs to reduce insect attack is now less commonly practised than in the past. After cracking, the nutmegs are now usually graded abroad into sizes representing 60/65, 80 or 110 to the lb. (Fig. 107). Elongated nutmegs, which fetch a lower price, and small or damaged ones are kept separate. Nutmegs are exported in barrels or cases containing about 1 cwt.

Macroscopical Characters.—Nutmegs are broadly oval in outline, from 2 to 3 cm. in length and about 2 cm. in breadth. If not heavily limed, the surface is of a brown or greyish-brown colour and is reticulately furrowed. At one end is a lighter coloured patch with brown lines radiating from the hilum, which is surrounded by a raised ring. From this an ill-defined furrow (the raphe) runs to the chalaza, at the opposite end of the kernel, where there is a small, dark depression. Odour, strong and aromatic; taste, pungent and slightly bitter.

A longitudinal section (Fig. 108, B) has a lustrous, marbled appearance. The outer tissue, which consists of dark brown perisperm, penetrates the light brown endosperm, the infoldings branching and giving rise to the marbled appearance.



FIG. 106.—Cracking nutmegs in Grenada. (From the Imperial Institute Collection.)



FIG. 107.—Grading nutmegs in Grenada. (From the Imperial Institute Collection.)

MYRISTICACEAE

The perisperm possesses fibrovascular bundles, the position of which is indicated by the reticulate furrows found on the outer surface.

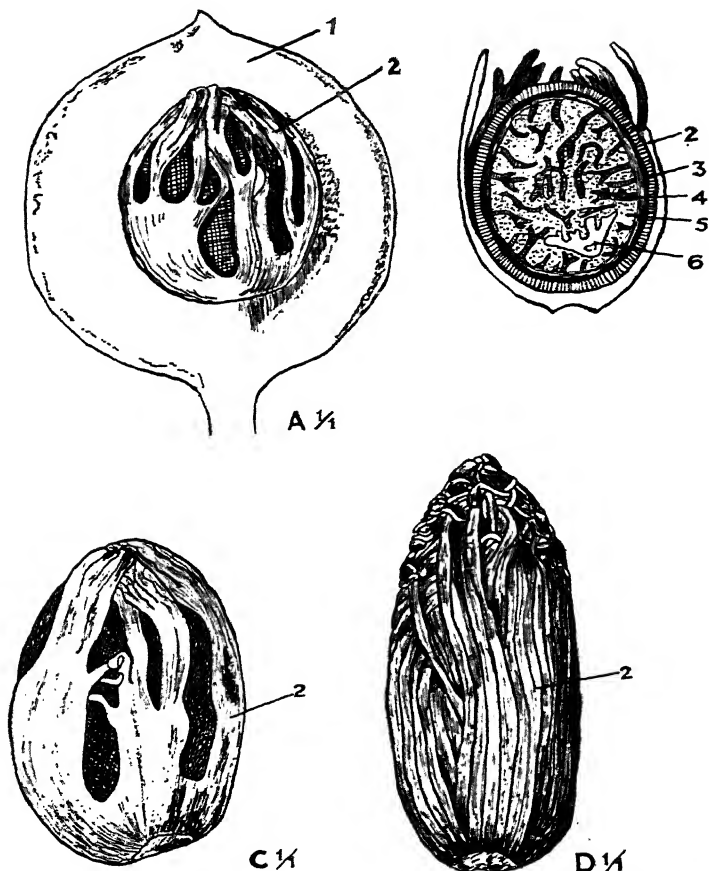


FIG. 108.—A, fruit of *Myristica fragrans*, with half of the pericarp removed. B, longitudinal section of the seed of same; C, seed of *M. argentea* (Papua nutmeg); D, seed of *M. malabarica* (Bombay nutmeg) 1, fleshy pericarp; 2, aril; 3, testa; 4, perisperm; 5, endosperm. 6, embryo. (A after Baillon, C and D after Thoms, *Handbuch der Pharmazie*.)

Microscopical Characters.—The microscope shows that the outer perisperm cells are radially flattened and have brownish contents, while the folds of perisperm consist of thin-walled parenchyma, rounded or oval oil cells and groups of spiral tracheids. The endosperm cells are parenchymatous. They have thin, brown walls and contain simple and compound starch grains, aleurone grains and fat, the latter often in crystalline masses. For powder, see p. 103.

Grades.—Well-rounded and graded nutmegs, without scorch marks or bruises, fetch the highest price. Unlimed ones are usually preferred in Britain. Up to 1933 Grenada nutmegs * were often ungraded, bruised and contained a proportion of very small kernels and "longs." They were therefore less esteemed than those from the East Indies. Efforts have now been made to remedy these defects.

Allied Drugs.—*Papua nutmegs* (Fig. 108, C) are derived from *M. argentea*, a tree grown in New Guinea. They are often taken to Macassar and enter commerce as Macassar, Papua, long or wild nutmegs. They are longer (about 3.5 cm.) than the official nutmegs, have a uniform, scurfy surface, little odour, and a disagreeable taste.

Bombay nutmegs (Fig. 108, D) are derived from *M. malabarica*, grown in India. They are very long and narrow and lack the characteristic aroma of the genuine drug.

Mace.—Common mace or Banda mace consists of the dried arillus or arillode of *Myristica fragrans*. This when fresh is of a bright red colour and is removed either by the finger or a knife. When removed entire it forms "double blade" mace, but if in two pieces it is known as "single blade" mace. After flattening, by treading under the feet or pressing between boards, the mace is sun-dried for from two to four days, when it acquires a golden-yellow colour and becomes brittle. Mace is usually packed in chests containing 280 lb.

Sections of mace show a thick-walled epidermis and a large amount of parenchyma in which are found fibro-vascular bundles and large oil cells. The parenchymatous cells contain somewhat angular masses of amylo-dextrin, which stain red when treated with solution of iodine. The oil (4 to 17 per cent.) is almost indistinguishable from that of the nutmeg.

Bombay mace (*M. malabarica*) and Papua mace

* See "The Nutmeg Industry in Grenada," *Bull. Imp. Inst.*, 1933, XXXI., 2, 197-218; and 1937, XXXV, 3, 289-297.

(*M. argentea*) are shown in Fig. 108. Bombay mace is a regular article of commerce although almost valueless as a spice. It is dark red in colour, lacking in aroma, and yields about 30 per cent. of extractive to light petroleum (genuine mace yields about 3.5 per cent.). Papua mace is distinguished by its shape, dull brownish surface, lack of aroma, and acrid taste.

Constituents.—Nutmegs yield from 6 to 15 per cent. of volatile oil and from 30 to 40 per cent. of fat; also phytosterin, starch, amylo-dextrin, colouring matter, and a saponin.

The volatile oil (*Oleum Myristicæ* B.P.) contains, according to Power and Salway (1907), pinene and camphene 80 per cent., dipentene 8 per cent., alcohols about 6 per cent., myristicin about 4 per cent., safrole 0.6 per cent., and eugenol and isoeugenol 0.2 per cent. Good oils when evaporated rapidly on a water-bath yield about 1 to 2 per cent. of residue (B.P. not more than 3 per cent.). Myristicin, $C_{11}H_{12}O_3$ (Semmler 1890, Thoms 1903), is 4-allyl-6-methoxy-1:2-methylenedioxybenzene. It is crystalline and, owing to its high boiling point, is mainly found in the last portions of the distillate. Myristicin is toxic to human beings and large doses of nutmeg or its oil may cause convulsions.

By expression or by means of solvents nutmegs yield a product known as "nutmeg butter" or expressed oil of nutmegs. This consists (Power and Salway, 1908) of 12.5 per cent. of volatile oil, 73 per cent. of trimyristicin (the glyceride of myristic acid, $C_{13}H_{27}COOH$), small quantities of oleic, linoleic and other acids, and about 8.5 per cent. of unsaponifiable matter. Inferior qualities, made from nutmegs which have been deprived of part of their volatile oil by distillation, may also be found in commerce.

Uses.—Nutmegs, maces, and their oils are largely used for flavouring and as carminatives. The expressed and volatile oils are also used externally for rheumatism.

Family LAURACEÆ

The family consists of 40 genera and about 1,000 species. The flowers are usually bisexual (e.g. *Cinnamomum*), rarely unisexual (e.g. *Laurus*). The floral parts are arranged in trimerous whorls, the two outer ones, which are alike, forming the perianth. Four whorls of stamens are typical but, owing to reduction, only three whorls are fertile in *Cinnamomum* and two or three in *Laurus*. The fruit is a berry or drupe.

All members of the Lauraceæ contain oil cells in the leaves and in the cortex, in which the secretion is suspended in a pouch from a cuticularised "basin." Mucilage cells are present in most species. The cork arises superficially at a rather late stage. Stone cells may often be found in the primary cortex of older branches, e.g. *Cinnamomum Cassia*. The groups of primary bast fibres are united by a pericyclic ring of stone cells many of which show a characteristic, U-shaped thickening, e.g. *Cinnamomum zeylanicum* and *C. Cassia*.

The bay laurel, *Laurus nobilis*, is the only European representative of the family; its evergreen leaves are used for packing stick liquorice, while the berries, which contain volatile oil and a high percentage of fat, yield expressed oil of bay. Two barks formerly used under the names of true coto and paracoto barks appear to have been derived from South American species of *Nectandra*. Cassia buds of commerce are the dried, immature fruits of one or more species of *Cinnamomum* (probably *C. Cassia* and *C. Lourerii*). In addition to oil of cinnamon and oil of cassia, the Lauraceæ yield many other volatile oils of commercial importance, e.g. oil of sassafras (from the root of *Sassafras officinale*), oil of linaloe, or "bois de rose femelle," and oil of camphor.

CINNAMOMI CORTEX

Cinnamomum, B.P.; Cinnamon Bark, Ceylon Cinnamon;
F. Cannelle de Ceylan; G. Zimmt, Ceylon Zimmt

Source.—The Pharmacopœia states that "cinnamon is the dried inner bark of the shoots of coppiced trees of *Cinnamomum zeylanicum* Nees, and is known in commerce as Ceylon cinnamon."

Many different varieties of *C. zeylanicum* exist in the wild state in Ceylon and Southern India. These wild barks are of varying quality but inferior to the official kind. *Cinnamomum zeylanicum* is cultivated not only in Ceylon but in S. India, Martinique, Cayenne, Jamaica, Brazil, and Seychelles. That grown in Ceylon is, however, the one most esteemed and is the variety normally met with in British commerce.

History.—References to aromatic barks of the cinnamon type are abundant in the Old Testament and in ancient Greek and Latin writings. Hanbury inclines to the opinion that

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"we must regard the ancient cinnamon to have been the substance now known as *Chinese cassia lignea* or *Chinese cinnamon*, and cassia as one of the thicker and perhaps less aromatic barks of the same group, such in fact as are still found in commerce." These barks were probably obtained from China, where cassia was known about 2,700 B.C., and it is not until the thirteenth century that any reference is found to the collection of cinnamon in Ceylon. Ceylon was occupied by the Portuguese in 1536, the Dutch in 1656, and by the English East India Company in 1796. The Dutch exercised a strict monopoly comparable with their monopoly of nutmegs. This was continued until the monopoly of the English East India Company was abolished in 1833. Cinnamon cultivation was started by the Dutch in 1770.

Cultivation, Collection, and Preparation.*—In Ceylon about 26,000 acres are devoted to cinnamon plantations. Most of the plantations are small and are situated in the Southern or Western Provinces. The industry is almost entirely in the hands of the Sinhalese. In 1937 the exports amounted to over 52,000 cwt. of quills and chips, valued at about £155,000, as well as over 11,000 oz. of cinnamon bark oil and nearly 3,000,000 oz. of cinnamon leaf oil.

Cultivation.—Cinnamon requires a rich but light soil, a rainfall of about 75 to 125 ins., and an average temperature of about 80° F. The *fresh* seeds are sown in seed beds or in holes on the plantation. The plants are finally arranged about 6 to 10 ft. apart. In the second or third year they are coppiced to within a few inches of the ground. About 5 or 6 shoots are then allowed to grow from the stump and are kept straight by pruning.

Cutting.—"Two or three times a year some of the shoots are cut, most of the crop being obtained from those which have been growing about eighteen months. At this age they are about 10 ft. long and rather more than an inch in diameter. Cutting lasts from April to December, the chief periods being after the heavy rains, when the bark peels most readily. These periods are April to July and October to December. The shoots are cut and the tops and twigs removed with an instrument known as a *kathé* (*catty*). The one illustrated in Fig. 109 (a) is 19 ins. long. About 50 lb. of quills per acre will

* For further details, see Trease and Pinto, P. J., 1938, March 26, 319, from which the following quotations have been taken.

be obtained from the first crop, about four years after planting, the yield increasing each year until the tenth, when about 150 to 180 lb. per acre may be expected. If the leaves are put into the soil the next crop is good, and vice versa. Large quantities of leaves, however, are used for the distillation of cinnamon leaf oil, and the factor which determines the mode of disposal of the leaves is the price which this oil fetches."

Peeling.—"Boys tie the sticks in bundles with coir string and take them to the peeling shed or *wadié* near the workers' huts. Removal of the bark and cork is facilitated by allowing 'fermentation' to take place for a few hours. The peeler

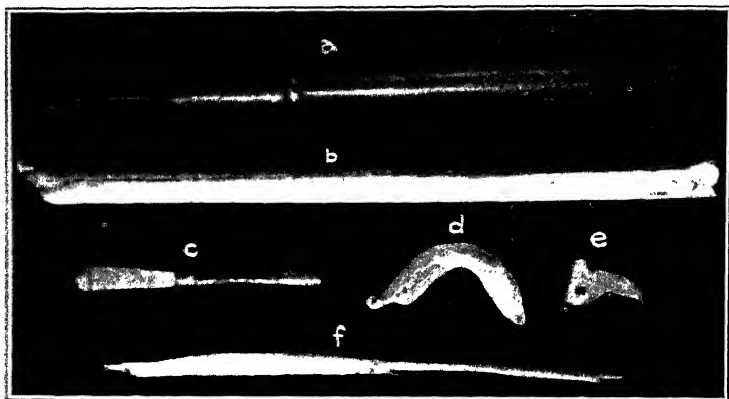


FIG. 109.—(a) Kathé; (b) half-peeled shoot; (c) peeling-knife; (d) steel scraper; (e) hard-wood rubber; (f) piece of bark: the end on the right has been scraped and therefore has curled most on drying. (*Pharmaceutical Journal.*)

(Fig. 110) uses the brass knife (Fig. 109 (c)) known as a *kochatté-talané*. He rings the bark at intervals of about 18 ins. and makes two longitudinal slits on opposite sides of the shoot, working the knife under the bark. If the latter does not separate readily it is rubbed with a piece of hard wood or the handle of the knife. Fig. 109 (b) shows a shoot with half the bark removed. The separated bark is wrapped in coir matting and allowed to 'ferment' overnight."

Scraping.—"The process used for the removal of the outer bark is shown in Fig. 111. A piece of wood of suitable size is supported at one end by a wall, as in the figure, or by means of

a small tripod of sticks tied together at the apex. Each piece of bark is placed in turn on the stick and held at its upper end by the scraper's foot whilst the cork and cortex are removed with the curved steel scraper, Fig. 109 (d), known as a *kochathé-gané*."

Making up.—"The process of making up the quills is

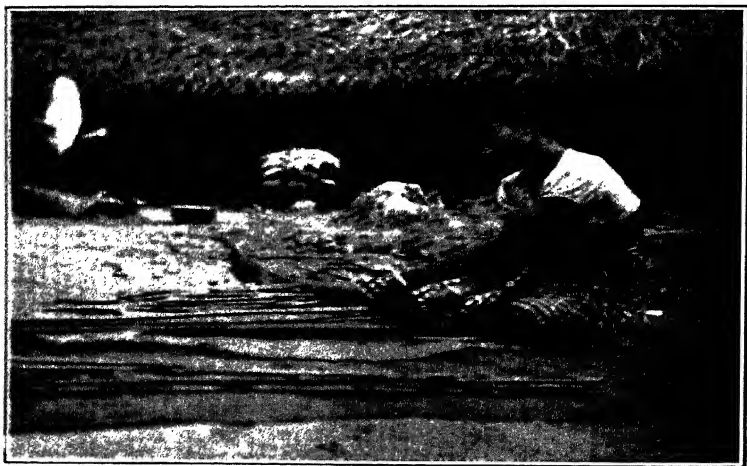


FIG. 110.—A native peeler using the brass peeling-knife shown in Fig. 109 (c). (*Pharmaceutical Journal*.)

illustrated in Fig. 112. The worker sits with a board and a measuring stick 42 ins. long, to which is attached a wooden lifter known as '*Peihi Kotuwa*.' This is laid on the right-hand side of the worker. The compound quill is assembled on the board, and when it has reached the required length the end is cut off with a pair of scissors and it is gently lifted, with the help of the lifter, on to a mat.



FIG. 111.—Scraping the bark with the steel instrument shown in Fig. 109 (d). (*Pharmaceutical Journal*.)



112.—Making up the compound cinnamon quills. The measuring board, stick and scissors should be noted. (*Pharmaceutical Journal*).

Drying.—"The quills are kept in the shade for about twenty-four hours, and on the second day are placed in the open air on wooden frames. Direct sun is apt to cause warping, and when there is danger of this the quills are covered with matting. After drying, the quills are sorted into grades and made into compact bales weighing about 100 lb. and enclosed in jute hessian, as in Fig. 113."

Grades.—The chief grades of cinnamon and their value (1938) in pence per lb. are as follows:—0000 1s. 0½d., 000 1s., 00 11½d., 0 11½d., No. 1 9d., No. 2 8½d., No. 3 8¼d., No. 4 8d., quillings 7¾d., featherings 6¼d., and chips 2¾d. Of the quills

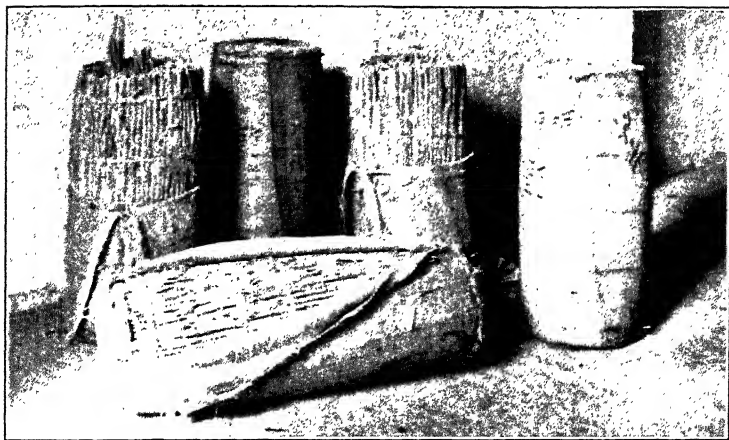


FIG. 113.—Bales of cinnamon, P.L.A. (*Chemist and Druggist*).

only small quantities of the fine or noughts range are produced, the greater part consisting of the Nos. 1 to 4 grades. Quillings and featherings consist of small pieces, the latter often containing some outer bark; they are used for grinding and for oil distillation. Chips consist mainly of outer pieces of bark and the oil derived from them has a lower specific gravity and a lower aldehyde content than that from the inner bark.

Macroscopical Characters.—Cinnamon is imported in large bundles which are enclosed in sacking (Fig. 113). These are about 40 inches in length. Pharmacists generally receive their supplies in shorter lengths known as "cigar lengths." The drug consists of single or double compound quills about 6 to

10 mm. in diameter and of varying length. In the different grades the thickness of each piece of bark varies considerably, but in good quality cinnamon it is usually not more than about

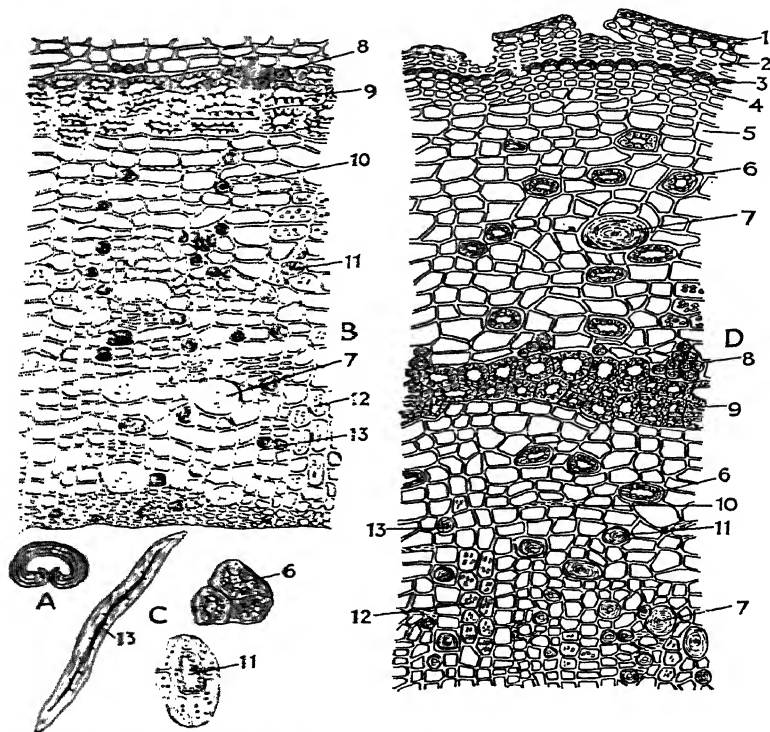


FIG. 114.—A, transverse section of a compound quill of cinnamon; B, transverse section of *Cinnamomum zeylanicum*; C, elements of the powder of the same; D, transverse section of the bark of *Cinnamomum Cassia*. 1, epidermis; 2, cork; 3, lignified cork; 4, phellogen; 5, primary bark; 6, stone cell; 7, mucilage cell; 8, bundle of sclerenchymatous fibres; 9, stone cell layers; 10, obliterated sieve tissue; 11, oil cell; 12, medullary ray; 13, bast fibre. (B and D after Gilg, C after Greenish).

0.5 mm., while the number of pieces of bark forming the compound quill varies from about ten to forty. The external surface of each piece is yellowish-brown and shows longitudinal,

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shining, wavy lines (pericyclic fibres), and occasional scars and holes (indicating the positions of leaves or twigs). The inner surface is somewhat darker and longitudinally striated. The bark breaks with a short, splintery fracture. Odour, fragrant; taste, warm, sweet, and aromatic.

Microscopical Characters.—Transverse sections of cinnamon (Fig. 114) show under the microscope a complete absence of epidermis* and cortex. Sclerenchymatous cells form a continuous ring about two to four cells deep with small groups of pericyclic fibres more or less embedded in it at intervals. The latter form the wavy lines on the outside of the commercial bark. The sclerenchymatous cells are usually much thickened on the inner, tangential and radial walls, and frequently contain starch. The medullary rays are one or two cells wide and contain numerous, acicular crystals of calcium oxalate about 5 to 8μ in length. Similar crystals are found in the phloem parenchyma, which also contains starch in compound and single grains, the latter not exceeding 10μ in diameter (those of *C. Cassia* often exceed this figure). The phloem fibres are isolated or in short, tangential rows. They are usually less than 30μ in diameter (those of *C. Cassia* measure 30 to 40μ in diameter). The secretion cells, which contain volatile oil or mucilage, are two or three times the diameter of the bast fibres and are axially elongated. For powder, see p. 110.

Constituents.—Cinnamon contains volatile oil (0.5 to 1.0 per cent.), phlobatannin, mucilage, calcium oxalate, and starch.

Official oil of cinnamon is required to contain not less than 50 per cent. w/w, and not more than 65 per cent. w/w of cinnamic aldehyde, $C_6H_5.CH:CH.CHO$, when estimated by the official process using *hydroxylamine hydrochloride reagent*.† Genuine oils also contain from 4 to 10 per cent. of phenols (chiefly eugenol), hydrocarbons (pinene, phellandrene, and caryophyllene), and small quantities of ketones, alcohols, and esters.

* In *C. zeylanicum* the cork, which is thin-walled and has its inner tangential walls sclerosed, is developed superficially at a rather late stage. According to Hartwich (cf. Solereder, p. 1043) "the pericyclic strengthening ring becomes thrown off in older stages owing to the formation of internal cork, its place being taken by a new ring of stone cells, which is formed for the most part from tissue belonging to the phelloderm."

† The aldehyde content of the oil, estimated by the bisulphite method, is given by Parry as 58 to 70 per cent. v/v (English distilled) or 63 to 76 per cent. v/v (Continental distilled), somewhat different methods of distillation probably accounting for differences in aldehyde content.

The oil is liable to adulteration with cinnamon leaf oil and with oil of cassia. The former contains from 70 to 95 per cent. of eugenol and yields a blue colour with solution of ferric chloride. Oil of cassia contains from 85 to 95 per cent. of aldehydes, gives a brown colour with ferric chloride solution, and frequently contains traces of lead as it is packed in lead containers. (See Fig. 105.)

Allied Drugs.—Cayenne cinnamon consists of the bark of cultivated plants of *C. zeylanicum* grown in French Guiana, Brazil, and some of the islands of the West Indies. It is generally obtained from older branches than the Ceylon drug and appears to be inferior to it in quality. It does not appear to be used to any extent in Britain.

Wild or jungle cinnamon (*C. zeylanicum*) is larger and darker than the cultivated product, and resembles cassia bark (see below). It is now rarely met with, its export from Ceylon being prohibited.

Saigon cinnamon (*Cinnamomum* U.S.P. XI, *Cinnamomum Saigonicum* U.S.P. IX) is obtained from wild trees of *C. Loureirii*, which are largely grown in the mountainous districts of Annam (French Indo-China). The plant, which is closely related to *C. Cassia*,* is also found in China and Japan. Large quantities of the bark are exported from the port of Saigon to the U.S.A. It resembles cassia bark more closely than cinnamon and occurs in quills up to 30 cm. long, 4 cm. wide, and 0.5 to 7.0 mm. thick. The outer surface is greyish-brown, warty, and ridged. The odour is coarser than that of Ceylon cinnamon and the taste sweeter.

Saigon cinnamon contains numerous single and 2-4 compound starch grains; single grains 5 to 25 μ (*cf.* Ceylon cinnamon).

Cassia, Chinese cinnamon, or cassia lignea.—Various barks have been imported under the name of cassia, including those now known as Saigon cinnamon and Java cinnamon or cassia vera (*C. Burmanii*). That now known in the London market as Chinese cassia lignea is derived from *C. Cassia* Blume (see footnote*), a tree cultivated in the south-eastern provinces of China (Kwangsi and Kwangtung). When about

*ail, *Traité de Matière Médicale*, p. 276, states that both are varieties of a single species, *C. obtusifolium* Nees, Saigon cinnamon being derived from *C. obtusifolium* var. *Loureirii* Perrot and Eberhardt (*C. Loureirii* Nees), and Chinese cassia from *C. obtusifolium* var. *Cassia* Perrot and Eberhardt (*C. Cassia* Blume).

six years old the bark is removed from the older branches, the twigs and leaves being used for distillation. The cork and cortex are partly removed by planing. The bark is then tied into bundles and exported in boxes, *via* Canton and Hong-Kong.

Cassia bark occurs in channelled pieces or single quills up to 40 cm. in length, from 1 to 2 cm. in width, and from 1 to 3 mm. in thickness. The outer surface is darker than that of Ceylon cinnamon and, owing to careless planing, shows patches of grey cork. The odour is coarser than that of cinnamon and the taste more astringent.

Transverse sections resemble cinnamon as far as the inner part of the bark is concerned, except that the starch grains and bast fibres are somewhat larger. Outside the sclerenchymatous ring, however, is found the cortex with small groups of sclerenchymatous cells and isolated oil cells, and several layers of dark brown cork cells (see Fig. 114, D).

Cassia yields from 1 to 2 per cent. of volatile oil, which, when pure, contains no eugenol but rarely less than 85 per cent. of cinnamic aldehyde. This oil is included in the U.S.P. XI, under the name of *Oleum Cinnamomi* and is required to contain not less than 80 per cent. by volume of this aldehyde. Large quantities of oil are distilled from the leaves and twigs as well as from the bark. It arrives from Hong-Kong in leaden vessels containing about 16½ lb., and is sold on its cinnamic aldehyde content. Free cinnamic acid in the oil is liable to act on the lead to some extent. Although inferior in flavour to the oil of *C. zeylanicum* it is cheaper and is described in many pharmacopœias.

Java cinnamon is derived from *C. Burmannii* Blume, and is used in Holland. It may be distinguished from ordinary cinnamon when in powder by the presence of tabular crystals of calcium oxalate. The oil contains about 75 per cent. of cinnamic aldehyde.

Oliver bark or black sassafras is obtained from the so-called Brisbane "white sassafras" tree, *C. Oliveri*, a native of Queensland. It is used locally as a cinnamon substitute. The bark is easily distinguished from the drugs mentioned above. It occurs in flat strips about 20 cm. long, 4 cm. wide, and 1 cm. thick. The outer surface is brownish, warty, and bears patches of greyish cork. It yields about 1 to 2.4 per cent. of volatile oil containing, according to Hargreaves (1916), pinene, *d*-camphor (18 to 20 per cent.), safrole (25 to 27 per cent.),

and eugenylmethyl ether (40 to 45 per cent.). The bark also contains tannin.

Uses.—Cinnamon is used as a flavouring agent and mild astringent.

CAMPHORA

Camphora, B.P. ; *Camphor* ; F. *Camphre* ; G. *Kampher*,
Kampfer, *Campher*

e.—Natural camphor is a white, dextrorotatory ketone, $C_{10}H_{16}O$, obtained from the wood of *Cinnamomum Camphora*. It is said (1930) that "approximately 77 per cent. of the world's camphor trees are found in Taiwan (Formosa), about 15 per cent. in Japan proper, and 8 per cent. in Southern China." Synthetic camphor, which is optically inactive, is prepared from pinene.

History.—Early references to camphor refer not to laurel camphor but to Borneo camphor, obtained from *Dryobalanops aromatica*, which found its way to Persia in the sixth century and Europe in the twelfth century. When laurel camphor was first prepared is not known. It is now obtained from Formosa, Japan, and China, but cultivation on a smaller scale is carried on in Ceylon, the Federated Malay States, Burma, Java, India, Africa, and Florida. On the Japanese annexation of Formosa (the principal source of supply) a Government monopoly of the camphor trade was set up in 1900. Since that date the gradual increase in commercial importance of the synthetic product has lessened the demand for the Japanese product.*

Preparation.—The best yield of camphor is obtained from trees upwards of fifty years old, a fact which helps to explain the small quantities produced in many of the countries mentioned above where cultivation has commenced during the

* According to a report of the U.S. Department of Foreign and Domestic Commerce, abstracted in the *C. and D.*, 1930, November 8, p. 594, the estimated world production of camphor is 25,000,000 lb. per annum of which 10 million lb. is natural and 15 million lb. synthetic. Of the latter figure 12 million lb. were produced in Germany and the remainder in France, Switzerland, and Italy.

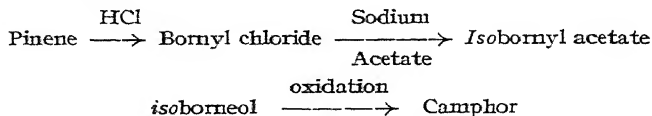
present century. Parry* describes the preparation of camphor as follows :—

“ The tree is felled and the young branches and twigs are chopped up and packed in perforated jars, and heated over a crude steam-bath. The steam enters the jars, saturates the chips, and causes the crude camphor to sublime and condense in earthenware pots placed over the jars. The crude camphor is sent to the port, and a certain amount of oil exudes from it which is collected and is known as oil of camphor. The majority of the oil is, however, produced by distilling the chips with water in crude stills. The crude product amounts to about 3 per cent. of the wood used. The oil is drained from the crystalline camphor, of which it retains a considerable amount in solution. This is transferred to a still, and about two-thirds is distilled off, leaving the bulk of the camphor in the residue, which is cooled and pressed to separate more camphor. This process is repeated so long as it pays, and the residue forms the camphor oil of commerce. . . .”

“ The crude camphor arrives in England in various states of purity, and is refined by sublimation, generally with quicklime and charcoal. Formerly camphor oil was regarded as having no value. To-day, however, it is used to an enormous extent in the preparation of saffrol, which is used as a cheap perfume, for the manufacture of artificial oil of sassafras, and for the synthesis of heliotropin.”

Camphor is refined in Japan, Europe, and the U.S.A. from the crude product, which contains about 90 per cent. of camphor. It is now sublimed into large chambers where it condenses into small crystals (“flowers of camphor”). From these the familiar blocks are made by hydraulic pressure.

Synthetic camphor is largely prepared from American turpentine, which is said to yield from 25 to 35 per cent. of camphor under suitable treatment. By the action of hydrogen chloride the pinene is converted into bornyl chloride, which, on treatment with sodium acetate yields *isobornyl acetate*. Hydrolysis of this to *isoborneol* and subsequent oxidation gives camphor.



* Parry's description, in his *Chemistry of Essential Oils*, is illustrated by photographs of camphor distilleries in Formosa. The procedure adopted in the province of Tosa, in Japan, will be found in the *U.S. Dispensatory*. Camphor was formerly purified by sublimation into large glass flasks (bomboloes), which when broken gave concave cakes about 10 inches in diameter (cf. *Pharmacographia*). A specimen of this form of “bell” camphor may be seen in the museum of the Pharmaceutical Society.

Characters.—Camphor occurs in small, colourless crystals or in transparent, fibrous blocks. It has a characteristic odour and a pungent, aromatic taste, which is followed by a sensation of cold. It volatilises at ordinary temperatures, forming an incrustation on the walls of the vessel in which it is kept.

Natural camphor is dextrorotatory (lævorotatory camphor occurs in the oil of certain species of *Artemisia*) but the synthetic product is almost optically inactive. If 0.1 G. of natural camphor be treated with 10 drops of a well-cooled mixture of equal parts of vanillin-hydrochloric acid and sulphuric acid it turns green and, after five hours, dark blue. This is due to traces of impurities as the synthetic camphor gives a yellowish colour with this test.

Allied Drugs.—Borneo camphor, obtained from *Dryobalanops aromatica* (Dipterocarpaceæ), and Ngai camphor, obtained from *Blumea balsamifera* (Compositæ), are used in China and Japan. In California camphor is produced from species of *Artemisia* (Compositæ).

Uses.—Camphor is used externally as a rubefacient, and internally as a mild antiseptic and carminative. It is also employed as a cardiac stimulant by injection, particularly in pneumonia. Large quantities (about 4 million lb. in 1930) are used in the manufacture of celluloid.

Family **RANUNCULACEÆ**

The Ranunculaceæ is a family including 30 genera and about 1,200 species. It is well represented in Britain. The flowers are bisexual, regular (e.g. *Ranunculus*) or zygomorphic (e.g. *Aconitum*). The perianth is simple or differentiated into calyx and corolla. The stamens are numerous and free. The carpels are usually numerous in the regular flowers or fewer in the zygomorphic ones. The fruits are typically tetraeries of achenes or of follicles.

ACONITI RADIX

Aconitum, B.P., *Aconiti tuber* I.A.; *Aconite*, *Aconite Root*; *F. Racine d'Aconit*; *G. Eisenhutknollen, Sturmhutknollen*

Source.—Aconite consists of the dried roots of *Aconitum Napellus*, collected from wild or cultivated plants. On the

Continent much wild aconite is collected, particularly in Germany and Switzerland, but the English root is obtained from cultivated plants.

Characters of Plant.—As there are some 60 species of *Aconitum*, which differ widely from one another in constituents, care must be taken to ensure that only the official species is used. *Aconitum Napellus* is grown in English gardens and is also found wild in certain localities, having apparently escaped from cultivation. It is a perennial herb with a tuberous root, which is replaced annually by one or more daughter roots. The latter develop as the result of growth of lateral buds produced on the upper part of the rootstock which, after elongating somewhat, produce an adventitious root crowned with a large, apical bud. Wild plants usually produce one daughter root, cultivated ones three or four. Many other species of *Aconitum* produces similar roots, while others produce rhizomes.

The apical bud of the daughter root commences to grow in the late winter or early spring, the parent root gradually perishing. The aerial stem is about 45 to 60 cm. in height in wild plants but frequently 1 to 1.5 m. in cultivated ones. The lower leaves are petiolate, the upper ones nearly sessile and form a tuft near the top of the stem before flowering. They are palmatisect, the lower into five to seven segments, the upper into three to five segments. Each segment is pinnatifid and linear-lanceolate. *The first leaves are pure green* (distinction from *A. paniculatum*, which have a bronze tint).

The inflorescence is a raceme of dark violet-blue, zygomorphic flowers. *These appear about the last week in May and last for a fortnight.* Each flower has five petaloid sepals, the posterior one forming a shallow, almost semicircular hood. Beneath the hood are two petals modified into large, stalked nectaries. The remaining petals, three to five in number, are inconspicuous. The stamens are numerous and surround three (occasionally five) carpels. The fruit is an etærio of three or five follicles.

History.—Plants of the genus *Aconitum* were known to the ancient Greeks, and were used as arrow poisons by the inhabitants of ancient China, Northern India, and probably Gaul. The drug was well known in mediæval times, but its introduction into regular medical practice was mainly due to Störck of Vienna in 1762.

Cultivation, Collection, and Preparation.—The aconite of English commerce is, generally speaking, of poor quality and

Holmes (1923) goes as far as to say that little or none is derived from true *Aconitum Napellus*. This is partly due to the importation of low-priced foreign aconites which make cultivation in this country unprofitable, and partly to the widespread formation of hybrids with other garden species. The points on which Holmes lays emphasis for the identification of true *Aconitum Napellus* (*Angelicum*) are those mentioned in italics in the description of the plant given above.

Aconite grows well on a peaty or leaf-mould soil containing a little lime. Propagation should always be by means of tubers as the seeds, besides being frequently sterile, may be produced as the result of hybridisation with other garden species.

Following the directions of the B.P. 1898, it is usual in England to collect the root in the autumn. On the Continent, however, collection from flowering plants is generally advocated,* the plant being then distinguishable from other wild species such as *A. variegatum* and *A. cammarum*.† After collection the tubers are dried. The tubers are not as a rule sliced but the brittle roots, although quite active, are often removed.

Macroscopical Characters.—English aconite, owing to the time of year at which it is collected, consists of both parent and daughter roots (Fig. 115), while the Continental consists mainly of parent roots. Both are obconical in shape, dark brown in colour, from 4 to 10 cm. in length, and from 1 to 3 cm. in diameter at the crown. Most of the drug of present-day commerce is of small size and frequently "wormy." The parent roots bear the remains of aerial stems and are more shrivelled than the daughter roots which bear large, apical buds. Rootlets may be present but these are usually broken

* The following portions of abstracts taken from consecutive pages of the *Y. B. Pharm.*, 1924, illustrate how opinion is divided as to the best time for collection: "The mature roots should be dug up in October" (Holmes, p. 266). "There appears to be enormous variation in the amount of alkaloids from aconite derived from different geographical sources; it is difficult to state whether these differences are due to the plant, or to the conditions under which it is grown. The collection of the drug in autumn is wrong. It should be collected in summer, when the inflorescence is expanding, or just before then. At that time the floriferous tubercles would be at their maximum alkaloidal strength, and could be used for pharmaceutical purposes, while the daughter tubercles could be replanted, to carry on the crop" (Goris and Metin, p. 267).

† A consignment of aconite sent to the U.S.A. and returned was found to consist of *A. cammarum* and *A. variegatum* (Casparis, *Schweiz. Apoth. Zeit.*, 1924, 62, 315).

off. The odour is usually slight but samples vary in this respect. Taste at first slightly sweet, followed by tingling and numbness (taste with care ; long chewing may be painful).

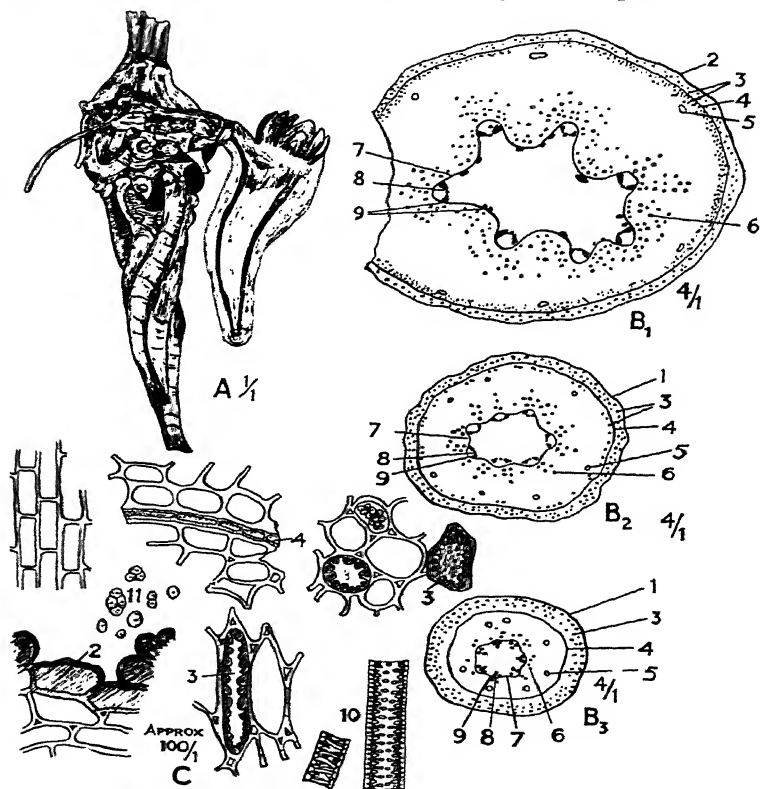


FIG. 115.—*Aconitum Napellus*. A, parent and daughter roots ; B₁, B₂, B₃, transverse sections of the daughter roots at different levels ; C, elements of the powder. 1, epidermis ; 2, metaderm ; 3, stone cells ; 4, endodermis ; 5, primary phloem ; 6, secondary phloem ; 7, cambium ; 8, primary xylem ; 9, secondary xylem ; 10, vessels ; 11, starch. (A, after Tschirch ; B, after Thoms, *Handbuch der Pharmacie* ; C, after Thoms and Gilg.)

Transverse sections of both parent and daughter roots show a stellate cambium with five to eight angles, a character found in many other species of the genus and therefore of small

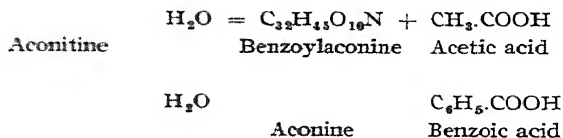
diagnostic importance. Sections taken from a daughter root are shown in Fig. 115. The amount of lignified tissue is small, the greater part of the root consisting of starch-containing parenchyma of the pith and secondary phloem.

Microscopical Characters.—Under the microscope a transverse section shows one or more layers of suberised cells with dark-coloured walls (metaderm); a primary cortex containing stone cells, separated by the endodermis and a region rich in stone cells from the phloem; the latter forms a large zone consisting of parenchyma with small scattered groups of primary and secondary phloem elements. Within each angle of the stellate cambium lies a small group of protoxylem with wedge-shaped masses of secondary xylem on either side. Small groups of secondary xylem also occur at other points immediately within the cambium.

In powder (Fig. 115, C) aconite may be identified by the large amount of parenchyma containing starch in compound grains with two to four components and single grains about 8 to 15 μ in diameter; also by the quadratic sclerenchymatous cells with large lumina and even thickening, the metaderm cells, and the vessels with simple slit-like pits or spiral thickening. Calcium oxalate and fibres are absent.

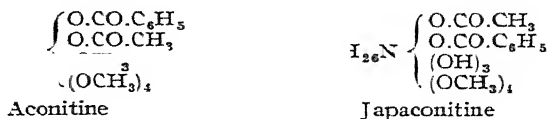
Constituents.—Aconite root contains the crystalline alkaloid, aconitine (Groves, 1860), and amorphous products of its hydrolysis, benzoylaconine (picraconitine) and aconine. The root also contains aconitic acid, $C_3H_3(COOH)_3$, and starch.

Many other species of *Aconitum* contain similar toxic aconitines, while others contain the less toxic aconines or the non-toxic atisines. The aconitines are diacyl esters of the aconines and can be readily hydrolysed by boiling with acids or alkalis. The hydrolysis of *Napellus* aconitine takes place on heating an aqueous solution, under pressure at 120° to 130°, according to the following equations:—



The aconines are polyhydroxyamino-alcohols containing

four methoxy groups, as will be seen from the formulæ of the aconitines of *A. Napellus* and *A. uncinatum* var. *japonicum*.*



On hydrolysis both the above yield benzoic and acetic acids but different aconines, that from japaconitine being distinguished as japaconine. The constituents of other toxic species of *Aconitum* may be seen in the following table :—

Variety	Alkaloid	Acyl Groups	Base
1. European—			
<i>A. Napellus</i>	Aconitine,	{ Benzoyl	Aconine
<i>A. Störckianum</i>	$\text{C}_{24}\text{H}_{47}\text{O}_{11}\text{N}$	{ Acetyl	
<i>A. Lycotconum</i>	Lycaconitine,	Lycotconyl †	Lycotconine.
	$\text{C}_{26}\text{H}_{49}\text{O}_{10}\text{N}_2$		
2. Japanese—			
<i>A. uncinatum</i> var. } <i>japonicum</i> }	Japaconitine,	{ Acetyl	Japaconine.
	$\text{C}_{24}\text{H}_{49}\text{O}_{11}\text{N}$	{ Benzoyl	
3. Indian—			
<i>A. deinothizum</i>	Pseudoaconitine,	{ Acetyl	Pseudoaconine.
<i>A. Balfourii</i>	$\text{C}_{26}\text{H}_{51}\text{O}_{12}\text{N}$	{ Veratryl	
<i>A. chasmanthum</i>	Indaconitine,	{ Acetyl	Pseudoaconine.
	$\text{C}_{24}\text{H}_{47}\text{O}_{10}\text{N}$	{ Benzoyl	
<i>A. spicatum</i>	Bikhaconitine,	{ Acetyl	Bikhaconine.
	$\text{C}_{26}\text{H}_{51}\text{O}_{11}\text{N}$	{ Veratryl	

Allied Drugs.—I. European Aconites.—Many years ago *A. paniculatum* was cultivated in England for medicinal use. It is said to produce rather small, curved tubers, which are relatively inactive. In 1924 a sample of Continental aconite was found to consist of the tubers of *A. cammarum* and *A. variegatum*. The above three species have blue flowers and produce tuberous roots resembling those of *A. Napellus*. In *A. cammarum* and *A. variegatum* "the connection between the mother and daughter roots is very short, which pulls the crown to one side and gives the root the appearance of a bird's head." ‡

* See also Rogers and Freudenberg, *Y. B. Pharm.*, 1938, 110.

† Lycotconic acid is succinylanthranilic acid,

$\text{COOH.C}_6\text{H}_4\text{.NH.CO.CH}_2\text{.CH}_2\text{.COOH.}$

‡ Abstract of paper by Casparis, *Y. B. Pharm.*, 1924, 265.

A. Storkianum, found in the Alps, usually produces three or four tuberous roots. *A. Lycototum* and *A. anthora* are yellow-flowered species, the roots of which are not likely to be mistaken for the official drug.

2. **Japanese Aconite.**—The Japanese aconite of European commerce is probably derived from *A. uncinatum* Linn. var. *japonicum* Regel. The roots found in commerce are shorter

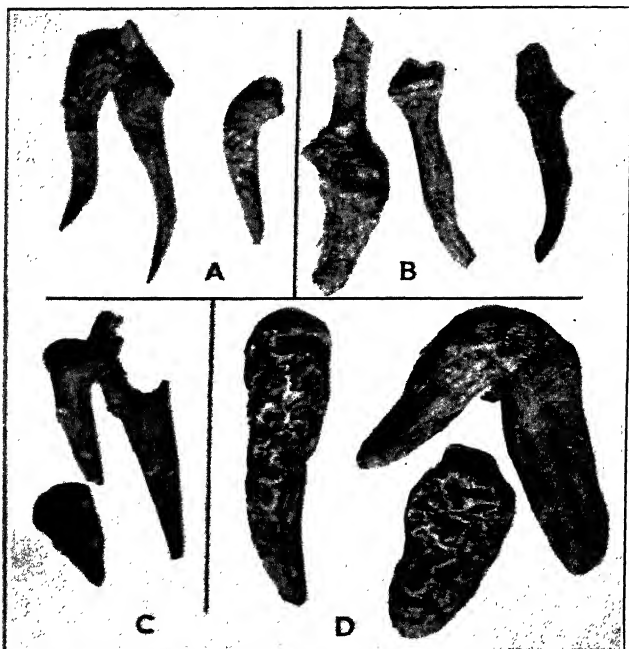


FIG. 116.—Aconite roots of commerce. A, English; B, German; C, Japanese; D, Indian (Newman).

and plumper than the official drug, and dark grey or brownish in colour. The surface is longitudinally ridged in the parent roots and nearly smooth in the daughter ones. The interior may be white and starchy or dark and horny. The root is usually said to have a circular cambium but roots have been observed in which it is distinctly stellate.

3. **Indian Aconites.**—Several Indian aconites have been

imported but that now usually found in commerce is derived from *A. deinorhizum*. The root is easily distinguished from that of *A. Napellus*. It usually consists of daughter roots about 15 cm. in length and about 4 cm. in diameter at the crown. The surface is dark brown and coarsely wrinkled. The drug is very hard and horny, the starch being usually gelatinised by excessive heating.* It contains the highly toxic alkaloid pseudoaconitine. This is also found in *A. Balfourii*, the roots of which have been imported. The roots of *A. chasmanthum*, containing indaconitine, have been found in American commerce. *Aconitum heterophyllum* yields atis

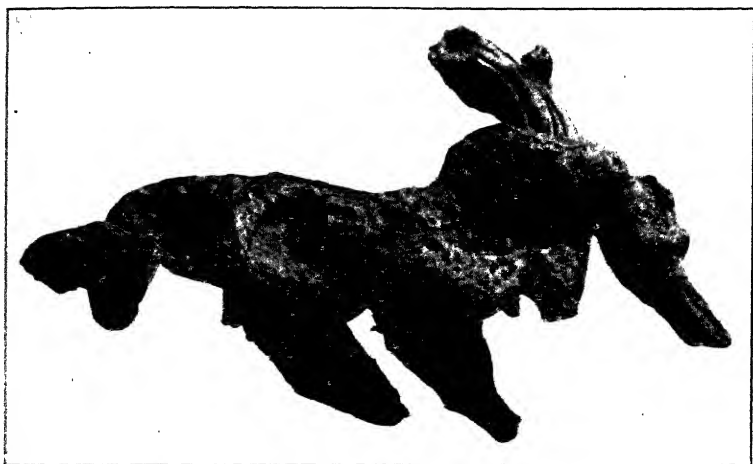


FIG. 117.—Soviet Aconite (Sutcliffe).

root, containing an amorphous alkaloid, atisine, which is much less toxic than the aconitines. The tubers, which are about 1.5 to 4 cm. in length and of an ash-grey colour, are used in India as a tonic. During recent months (1938) Indian aconite, guaranteed to be from *A. Napellus*, has been imported.

4. **Soviet Aconite.**—During the last few years shipments of Soviet aconite have been received in London. The drug is

* For an account of the anomalous structure of the roots of various species of Indian aconite, in which the central parenchymatous ground tissue develops vascular strands, see Solereder, p. 506. *A. heterophyllum*, *A. deinorhizum*, and *A. Balfourii* are among the species there mentioned.

easily recognized by the fact that a considerable number of tubers are often united together in a row (Fig. 117). In response to inquiry made by the author, the U.S.S.R. Institute of Plant Industry inform us that the plant is grown in Kazakstan and Khirghistan, and state "It is a Tian Shan geographical race of *Aconitum Napellus* L., which has been described by our botanists, B. A. Fedchenko and L. Utkin, under the name of *Aconitum tianschanicum*. This description will be published in an early issue of the *Bulletin of Applied Botany, Genetics and Plant Breeding*. The 'Tuber Aconiti' of this race are noted for their high alkaloid content." The latter statement is confirmed by analyses made here, which give 1.41 and 1.58 of ether-soluble alkaloids in two samples examined.

The physiological properties and chemical nature of the alkaloids are being investigated by my colleagues, H. H. Barber and F. R. Mumford. Preliminary biological tests on tinctures made from equal weights of a good Hungarian sample of *Aconitum Napellus* and from the Soviet drug showed that the Soviet tincture exhibited the higher potency when assayed on frogs. A sample of the crude alkaloids was extracted, and from this mixture an alkaloid identical with the aconitine of *A. Napellus* was isolated. The details of this investigation will shortly be published.

Assay.—As mentioned in the Introduction to the Pharmacopœia there is no trustworthy chemical method of assay for this drug. Owing to the different toxicities of the aconitines and aconines, the assay of total alkaloids is of little value. Biological methods of assay, although not officially recognised, are sometimes applied to the drug.

Uses.—Aconite is used internally in fevers and externally for neuralgia and rheumatism. In addition to the official drug, large quantities of Indian and Japanese aconites are sold, the ultimate destination of which is a matter for conjecture.

HELLEBORI NIGRI RHIZOMA

Black Hellebore Rhizome ; F. Hellébore Noir ; G. Schwarze Niesswurzel, Winterrose

Source.—Black hellebore rhizome is obtained from *Helleborus niger*, a perennial herb indigenous to Central Europe but

cultivated in English gardens. Two similar species, *Helleborus viridis* and *H. fetidus*, are indigenous to Britain. The drug is chiefly collected in Austria and Germany.

Characters.—The drug occurs in irregularly branched, blackish pieces from 3 to 6 cm. in length and from 5 to 8 mm. in diameter. The branches show encircling leaf scars and the remains of the aerial stems or buds. Only a few roots are usually found in the commercial drug.

Transverse sections of the rhizome show considerable variation, there being from four to twelve or more vascular bundles often of widely different shapes.* In the roots the wood has a somewhat stellate form (cf. *Cimicifuga* and *Aconitum*).

Constituents.—Black hellebore contains two crystalline glycosides, helleborin and helleborein. The latter is a chromogenic saponin yielding on hydrolysis helleboretin, glucose, and acetic acid with the production of a violet colour. An infusion gives no dark colour with ferric chloride (distinction from *cimicifuga*).

Uses.—The drug is occasionally employed as a purgative in veterinary practice but is obsolete in ordinary medicine.

CIMICIFUGÆ RHIZOMA

Cimicifuga, N.F.; *Actæa Racemosa* Radix; *Cimicifuga*, Black Snakeroot, Black Cohosh; F. Racine d'Actée à Grappes; G. Schwarze Schlangenwurzel

Source.—Black snakeroot is the dried rhizome of *Cimicifuga racemosa* Elliot (*Actæa racemosa* Linn.). It is collected in the U.S.A. (Michigan, Illinois, Indiana, and Kentucky).

Characters.—The drug occurs in dark brown pieces about 4 to 12 cm. in length and 1 to 2.5 cm. in diameter (Fig. 92). The rhizome bears numerous, characteristically curved branches about 3 cm. in length. The latter show encircling leaf scars and terminate in a cup-shaped scar or in a bud. Numerous dark brown roots, from 3 to 12 cm. in length and from 1 to 3 mm. in diameter, are produced on the lower surface of the rhizome but many of these are broken off in the commercial drug. It is hard and horny, has a disagreeable odour which is, however, lost with age, and a bitter, acrid taste.

* Wallis and Saunders (*Y. B. Pharm.*, 1924, 664), after a careful comparative study of the rhizomes of *H. niger* and *H. fetidus*, were unable to find any constant characters by means of which the two rhizomes could be distinguished. The same also appears to be true of *H. viridis*.

In section the rhizome shows a thin, dark brown cortex, numerous radiate, yellowish wood bundles, separated by dark brown medullary rays, and a large pith. The branches have a similar structure but relatively small pith. The roots have a thick brownish bark and a central, yellowish wood with four, five, or six rays (usually four, arranged like a Maltese cross).

Constituents.—*Cimicifuga* contains about 15 to 20 per cent. of resinous substances (cimicifugin), which separate on pouring



FIG. 118.—Rhizome of *Cimicifuga racemosa* (Newman).

a concentrated tincture into water. According to Finnemore (1910), the drug contains three crystalline bodies (apparently alcohols, but requiring further investigation); phytosterol; palmitic, oleic, and isoterulic acids,* and possibly an alkaloid.

Uses.—*Cimicifuga* has been recommended in the treatment of chorea. It has also been used, but with less success, for rheumatism, urticaria, neuralgia, and dysmenorrhoea.

* Tannin is sometimes stated to be present. Ware (in a private communication) states "there is no tannin present, in any appreciable quantity at any rate. The colour reaction given by iron is probably mainly due to acid, which is phenolic, and related bodies."

STAPHISAGRIÆ SEMINA

Pedicularis ; *Stavesacre Seeds* ; *F. Staphisaigre* ;
G. Stephanskörner, Läusekörner

Source.—Stavesacre seeds are obtained from *Delphinium Staphisagria*, an annual or biennial herb cultivated in Italy and other Mediterranean countries.

Characters.—The seeds are obscurely triangular or quadrangular in outline, and about 6 mm. long. The testa is dark brown but usually covered with greyish dust. It is deeply reticulated. Sections show a large, oily endosperm in which a small embryo is embedded. The latter lies at the more pointed end of the seed, where the hilum may be seen. The endosperm has a bitter, intensely acrid taste.

Constituents.—The seeds contain about 1 per cent. of alkaloids and from 30 to 35 per cent. of fixed oil. The chief alkaloid present is delphinine, $C_{34}H_{47}O_9N$, a crystalline base isolated by Brandes (1819). Other alkaloids present are delphisine (crystalline), delphinidine (amorphous), and staphisagrine (amorphous).

Uses.—The seeds are used in the form of an ointment as a parasiticide. The alkaloids are extracted together with the oil.

Family **BERBERIDACEÆ**

Genera 9, species 150. Perennial herbs or shrubs. The flowers are hermaphrodite, regular, and hypogynous. The perianth is differentiated into calyx and corolla. The stamens are generally in two whorls. The ovary is usually comprised of one carpel. The fruit is a berry (rarely an achene) ; seeds one to numerous.

In some members of the family there is a close resemblance to members of the Ranunculaceæ, *Hydrastis*, for example, being sometimes placed in the Ranunculaceæ in the same tribe as the Peony. The occurrence of the alkaloid berberine in the Ranales and the succeeding order, the Rhœadales, is of interest.* It is found in :

Order **RANALES**

Family Ranunculaceæ, *e.g. Coptis*.

Family Berberidaceæ, *e.g. Berberis*
and *Hydrastis*.

Family Menispermaceæ, *e.g. Coscinum*.

* Berberine is also found in the Rutaceæ (species of *Xanthoxylum*, *Toddalia*, etc.).

Order RHŒADALES Family Papaveraceæ, e.g. *Argemone* and *Chelidonium*.

Other alkaloids in these families are chemically related, e.g. hydrastine (from a member of the Berberidaceæ) is related to narcotine (from a member of the Papaveraceæ).

The stem of an Indian species of *Berberis* (*B. aristata*) was formerly official and the dried bark of our indigenous *Berberis vulgaris* is used in medicine.

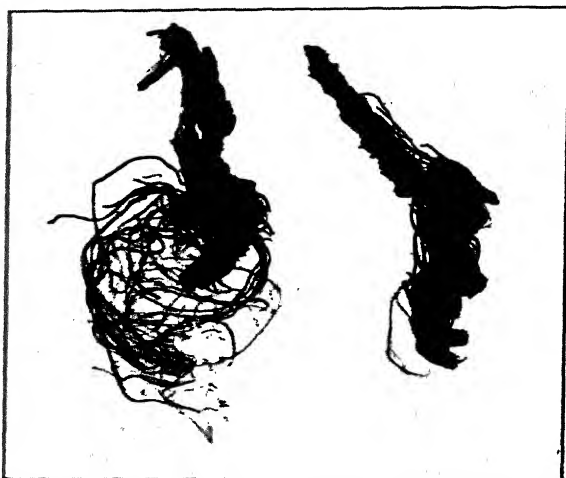


FIG. 119.—Rhizomes and roots of *Hydrastis canadensis* (Sutcliffe).

HYDRASTIS RHIZOMA

Hydrastis ; Golden Seal, Yellow Root ; F. Racine d'*Hydrastis du Canada* ; G. Canadische Gelbwurzel

Source.—*Hydrastis* consists of the dried rhizome and roots of *Hydrastis canadensis*, a small perennial plant indigenous to the woods of eastern Canada and the eastern U.S.A. The wild plants have been exterminated in many districts but are still found in parts of Virginia, Ohio, Kentucky, and Indiana. The greater part of the commercial drug is now obtained from cultivated plants grown in America and in Europe.

Cultivation, etc.—Cultivation presents considerable difficulty, the plants taking about five years to produce a saleable

rhizome and being liable to fungal and other diseases.* The rhizomes are collected in the autumn and dried.

History.—The use of hydrastis, both as a drug and as a dye, was learnt by the early European settlers from the Cherokee Indians.

Characters.—The drug consists of almost cylindrical rhizomes about 1 to 5 cm. in length and from 2 to 10 mm. in diameter (Fig. 119). The rhizomes grow more or less obliquely and bear numerous, short branches, which terminate in cup-shaped scars and bear encircling cataphyllary leaves. Similar

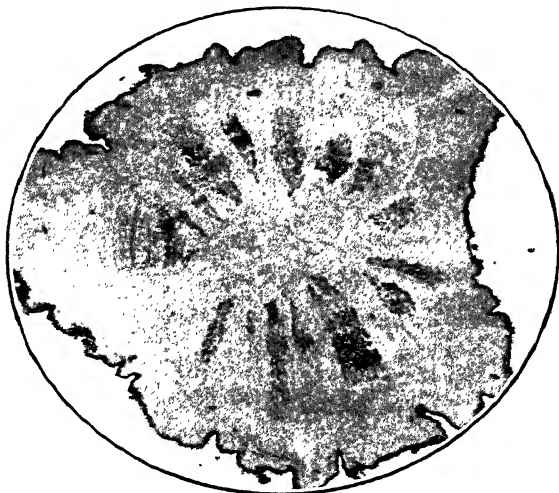


FIG. 120.—Transverse section of hydrastis rhizome (Sutcliffe).

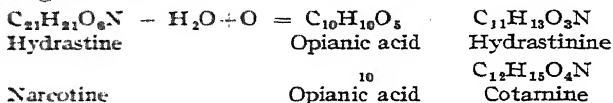
scale leaves are found on the rhizome, the outer surface of which is yellowish-brown or greyish-brown. The roots, which originate on the ventral and lateral surfaces, are long and wiry and, in the commercial drug are often broken at a distance of a centimetre or so from the rhizome. The drug breaks with a short, waxy fracture. It has a slight but distinctive odour and bitter taste.

A transverse section of the rhizome (Fig. 120) shows a fairly

* For details of hydrastis cultivation, see Thoms, *Handbuch der Pharmazie*, Band V, p. 223, and Hirose and Langenhan, *J. Amer. Pharm. Ass.*, 1930, 349 and 449. The latter workers show that considerable decomposition of hydrastine into hydrastinine and opianic acid takes place if the temperature of drying exceeds 35°.

thick, yellow or yellowish-brown bark ; from twelve to twenty radially-elongated, bright yellow wood bundles, separated by wide medullary rays ; and a large pith. The roots show a suberised hypodermis, a starch-containing cortex, a slightly lignified endodermis, and a small, central wood with two to six rays.

Constituents.—Hydrastis contains at least three alkaloids, namely, hydrastine, $C_{21}H_{21}O_6N$, berberine, $C_{20}H_{19}O_5N$, and canadine, $C_{20}H_{21}O_4N$. Commercial samples yield 1.5 to 4 per cent. of hydrastine and 0.5 to 6.0 per cent. of berberine. The former, which was isolated by Perrins (1862), forms colourless prisms, the latter reddish-yellow needles. The drug also contains resinous substances, starch, phytosterin and a little volatile oil. On treatment with dilute nitric acid, hydrastine undergoes hydrolytic oxidation, the reaction closely resembling that which takes place when narcotine is heated with the same reagent, i.e. :



Hydrastis yields 5 to 8 per cent. of ash and not more than 3 per cent. of acid-insoluble ash. Powdered hydrastis yields a characteristic, crystalline sublimate of hydrastine when gradually heated in a crucible covered with a glass slide.

Adulterants.—Adulterated hydrastis has frequently been found in commerce, but the detection of substitutes presents little difficulty.*

PODOPHYLLI RHIZOMA

Podophyllum, B.P. ; *Podophyllum Rhizome*, May-apple Root, Wild Mandrake ; F. *Rhizome de Podophyllum* ; G. *Fussblattwurzel*

Source.—*Podophyllum* consists of the dried rhizome and roots of *Podophyllum peltatum*, a perennial herb common in moist, shady situations in the eastern parts of Canada and the U.S.A. The drug is collected in Virginia, Kentucky, North Carolina, Tennessee, and Indiana.

* For an account of numerous adulterants, see Blague and Abstracts in *P.J.*, 1926, **33**, 142.

BERBERIDACEÆ

Collection.—The rhizome, which is about a metre in length, is dug up,* cut into pieces about 10 cm. in length, and dried.

History.—The drug has long been used by the Indians as a vermifuge and emetic and was introduced into the 1864 Pharmacopœia.

Macroscopical Characters.—Podophyllum occurs in sub-cylindrical, reddish-brown pieces about 5 to 20 cm. long and 5 to 6 mm. thick. The outer surface is smooth (autumn rhizome) or wrinkled (summer rhizome). The nodes are



FIG. 121.—Podophyllum. American above, and Indian below (Sutcliffe).

enlarged to from two to three times the diameter of the internodes. On these swellings the remains of the aerial stems are visible on the upper surface as large, cup-shaped scars surrounded by the remains of cataphyllary leaves some of which

* Russell, *Amer. J. Pharm.*, 1918, 90, 9, states that the drug is gathered at all seasons but "the greatest percentage of resin was found in the early spring-collected drug, and this resin conforms closely to the Pharmacopœial requirements." The best time for collection would seem to be in the autumn, after the aerial parts have died down, as although abundant resin is present in the early spring it rapidly decreases in amount when the plant begins to put out aerial shoots.

have buds in their axils. On the lower side of each node are about five to twelve root scars or portions of roots. The latter, if entire, are from 2 to 7 cm. in length and about 1.5 mm. in diameter. The drug breaks with a short fracture and shows a starchy or horny interior. Odour, slight; taste, disagreeably bitter and acrid.

Microscopical Characters.—A transverse section of the rhizome (Fig. 122) shows a dark-coloured epidermis, one or two layers of cork cells, a large collenchymatous and parenchymatous cortex and pith, and a ring of from twenty to thirty small, vascular bundles. The small vessels of the latter have

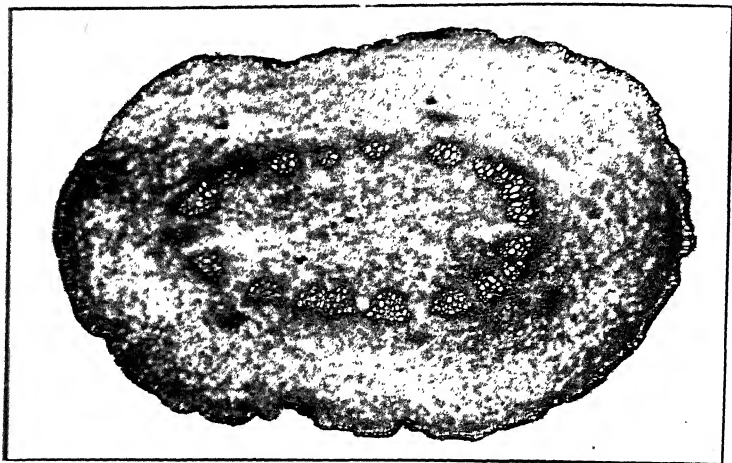


FIG. 122.—*Podophyllum peltatum*. Transverse section of rhizome (Sutcliffe).

simple pores or reticulate thickening. Many of the cells of the ground tissue contain reddish-brown masses of resin, cluster crystals of calcium oxalate, and starch. The cluster crystals are 30 to 60 to 100 μ in diameter, many exceeding 60 μ .* (Cf. Indian *Podophyllum*.) The starch occurs in simple grains 3 to 15 to 25 μ in diameter and in compound grains with two to fifteen components. In those rhizomes breaking with a horny fracture the starch shows gelatinisation. The roots have a central wood occupying about one-sixth of the total diameter.

* Wallis and Goldberg, "The Histology of *Podophyllum*," *Y. B. Pharm.*, 1937, 40-51

Constituents.—Podophyllum owes its purgative action to about 3 to 8 per cent. of resin, often known as podophyllin, which may be prepared by pouring an alcoholic extract of the drug into water, and collecting and drying the precipitate. The drug also contains starch and calcium oxalate. Ash about 3 per cent.

The crude resin contains podophyllotoxin, $C_{15}H_{14}O_6$ (forming 0.2 to 1.0 per cent. of the rhizome), a purgative crystalline substance; podophylloresin, an amorphous purgative resin; picropodophyllin (see below); and quercitin, $C_{15}H_{10}O_7 \cdot 2H_2O$, a yellow crystalline flavonol. Podophyllum Resin B.P. may be prepared from either American or Indian podophyllum (*P. emodi* below).

Podophyllotoxin on treatment with alkalis takes up a molecule of water and forms a gelatinous, unstable acid, podophyllic acid. The latter by loss of water forms crystalline picropodophyllin (an isomer of podophyllotoxin). An official test for the distinction of the resins of *P. peltatum* and *P. emodi* appears to be based on the gelatinisation of podophyllotoxin by alkali and the fact that the resin prepared from the Indian drug is richer in this constituent than the American.

Uses.—Podophyllum is used, mainly in the form of resin, as a drastic but slow-acting purgative. It is frequently prescribed with other purgatives and with henbane or belladonna to prevent griping.

PODOPHYLLI INDICI RHIZOMA

Podophyllum Indicum, B.P. ; Indian Podophyllum

Source.—Indian podophyllum consists of the dried rhizome and roots of *Podophyllum emodi* Wall., a perennial herb found in Thibet and Afghanistan.

Macroscopical Characters.—The drug, at first glance, shows little resemblance to American podophyllum. The roots frequently break off and some samples consist almost entirely of rhizomes (Fig. 121), while others consist largely of roots.

The rhizomes occur in much contorted pieces of an earthy brown colour, about 2 to 4 cm. long and 1 to 2 cm. in diameter. The internodes are much shorter than in the American drug with the result that each piece bears the remains of about three to six branches ending in cup-shaped scars, and about twenty to forty roots or root scars. The odour and taste resemble the

American drug. The rhizome is hard and somewhat difficult to break. Internally it is pale brown in colour and horny (usually) or starchy.

Microscopical Characters.—The general arrangement of the tissues resembles that found in American podophyllum, but the vascular bundles are more elongated radially. The calcium oxalate cluster crystals are fewer and smaller, 20 to 30 to 60 μ .

The starch grains are simple or 2–20 compound; individual grains 2 to 7 to 34 μ * (cf. American podophyllum).

Constituents.—Indian podophyllum closely resembles American podophyllum in constituents, but the amount of resin (10 to 12 per cent.) and podophyllotoxin (1 to 4 per cent.) is greater. The resin usually contains about twice as much podophyllotoxin as that prepared from *P. peltatum* and can be distinguished by the Pharmacopœial test based on the relative solubilities of the two resins in ammonia.†

The drugs may be distinguished chemically by adding a few drops of strong solution of copper acetate to a filtered alcoholic extract prepared from each. *P. peltatum* gives a bright green colour and no brown precipitate, while *P. emodi* gives a brown precipitate but no green colour.

Uses.—Indian podophyllum is used for the preparation of the resin and closely resembles the American drug in its action.

Family MENISPERMACEÆ

A tropical family of 70 genera and about 300 species. The members are generally lianes with palmately-lobed leaves and dioecious flowers. Anomalous stem structure is frequently found and abnormal secondary growth takes place in the roots of some genera, e.g. in the root of true *Pareira brava*, *Chondrodendron tomentosum*, a drug formerly official but now seldom used, successive cambia are produced giving rise to concentric rings of wood. The root structure of *Calumba* and the stem structure of *Coscinium fenestratum* are, however, normal. The broad primary medullary rays found in the stem of *Coscinium* are a family characteristic. The fruit is a drupe the dorsal

* Wallis and Goldberg, "The Histology of Indian Podophyllum, Y. B. Pharm., 1937, 311–318.

† Cf. Dott, "The Official Tests for Resins of Jalap, Podophyllum, and Ammonium," P.J., 1930, 213; see also P.J., 1930, 287.

side of which develops more rapidly than the ventral so that the apex lies close to the base, e.g. in the fruits of *Anamirta paniculata*, commonly known as cocculus indicus or fish berries.

CALUMBÆ RADIX

Calumba, B.P. ; *Calumba Root* ; F. *Racine de Colombo* ;
G. *Kolombowurzel*

Source.—*Calumba* is the dried, sliced root of *Jateorhiza palmata* (Lamarck) Miers, a dioecious climbing plant indigenous to the forests of Mozambique (Portuguese East Africa) and Madagascar.

History.—The drug was introduced into Europe by the Portuguese in the seventeenth century, but does not appear to have been very extensively used until its introduction into the London Pharmacopœia in 1788. Like many East African drugs, it frequently reached Europe *via* India, and it was formerly thought that its name was derived from the town of Colombo in Ceylon. Actually it is derived from *Kalumb*, the African native name for the root.

Collection.—The plant possesses a somewhat slender rhizome from which numerous large, fusiform roots are given off. These are dug up during dry weather (March), the rhizomes rejected, and the roots cut into transverse or oblique slices and dried in the shade. The drug is usually packed in bags each containing about 1 cwt. The root as imported, "natural calumba," is of an earthy brown colour owing to adhering soil. This is frequently removed by washing and brushing and the drug graded, the product being known as "washed calumba."

Macroscopical Characters.—*Calumba* occurs in circular or oblique slices according to whether the root has been sliced transversely or obliquely (Fig. 123). These are usually from 2 to 8 cm. in diameter and from 3 to 12 mm. in thickness. The centre, being less woody and less starchy than the remainder of the section, is usually much depressed owing to shrinkage during drying.

The cork is thin, greyish-brown or reddish-brown in colour and longitudinally wrinkled. Within it lies a broad, greenish-yellow zone which extends to the cambium and contains in its outer part isolated sclerenchymatous cells within which are dark grey, sinuous strands of sieve tissue. The greyish wood, which is separated from the bark by a dark cambium line,

shows numerous narrow, radiating lines of yellow vessels separated by abundant parenchyma. Some pieces show two or more concentric zones of wood. The fracture is short and starchy; odour, slight and somewhat musty; taste, bitter.

Microscopical Characters.—Under the microscope the drug is characterised by the sclerenchymatous cells, which have unevenly thickened, yellow walls and contain a number of prisms of calcium oxalate; by the abundant parenchymatous cells containing starch grains, each grain measuring about

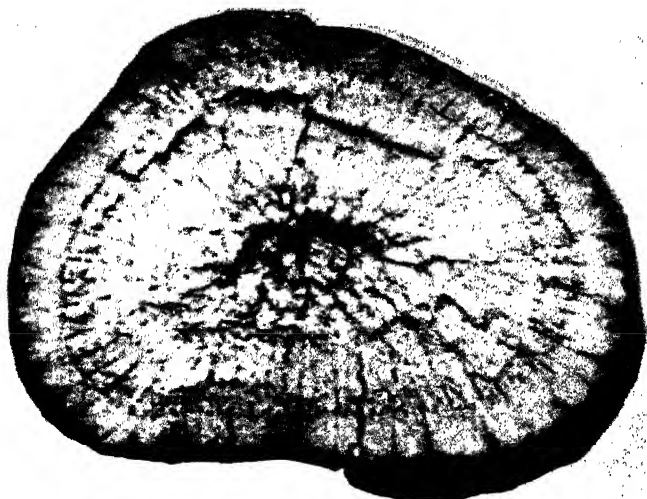


FIG. 123.—Calumba Root (Newman).

20 to 85 μ in length and having an eccentric, very distinct, radiate or cleft hilum; and by the yellow reticulate vessels. The walls of both the sclerenchymatous cells and vessels on treatment with 60 per cent. v/v sulphuric acid change colour from yellow to green.

Substitutes and Adulterants.—Calumba is rarely adulterated, but the supply is erratic and adulteration is more likely in times of shortage than when a liberal supply is available.

Calumba frequently contains occasional slices of *calumba rhizome*. These average about 2 to 3 cm. in diameter. The

structure is markedly radiate and, owing to its greater woodiness in that region, is not depressed in the centre. Ash, 12 to 17 per cent.

Ceylon calumba, the stem of *Coscinium fenestratum*, is rarely cut into transverse slices and more closely resembles berberis stem than calumba. The transverse section shows very distinct medullary rays and hoop-like bands of sclerenchyma outside each group of phloem.

Constituents.—Calumba contains about 2 to 3 per cent. of alkaloids and non-alkaloidal bitter principles, about 30 per cent. of starch, mucilage and traces of a fluorescent substance.* It contains no tannin. The drug yields about 4 to 7 per cent. of ash, higher ash values indicating badly cleaned root or the presence of calumba rhizome (B.P. "ash, not more than 9 per cent.").

The work of Gunzel (1906), Feist (1907), and Feist and Sandstedt (1918) pointed to the fact that calumba contained three quaternary bases. These were not obtained in the free state but in the form of iodides and were named *palmatine* "columbamine" and "jateorrhizine." Feist and Dschu (1925) state that the bases previously described as "columbamine" and "jateorrhizine" have proved to be mixtures of palmatine and a new phenolic base to which the name *jateorrhizine* is now applied. Spaeth and Burger (1926) report the isolation of a third base *columbamine*.

The non-alkaloidal, crystalline, bitter principles are known as columbin and "chamantherin." The former appears to be a lactone of a yellow, amorphous acid, columbic acid, which it yields on treatment with acids or alkalis.

Uses.—Calumba is used as a bitter tonic and, as it contains no tannin, may be prescribed with iron salts.

COCCULI FRUCTUS

Cocculus Indicus ; *Levant Berries*, *Fish Berries* ; F. Coque du Levant ; G. Kokkelskörner, Fischkörner

Source.—*Cocculus indicus* consists of the dried fruits of *Anamirta paniculata*, a climbing shrub found in south-eastern Asia (particularly the Malabar coast of India) and the East Indies. The natives collect the red, reniform, drupaceous

* Slices of calumba examined in filtered ultra-violet light appear intensely yellow, with the cambium and phloem showing a dark green colour.

fruits and dry them in the sun when they become blackish in colour. They are largely exported from Bombay and Madras.

Characters.—As in other members of the Menispermaceæ the dorsal side of the fruit grows more rapidly than the ventral with the result that the fruit becomes reniform and the base and apex both lie on the concave side. The base bears a small, circular scar left by the removal of the stalk, from which runs a ridge to the slightly pointed apex. The pericarp is rough and woody. Sections cut in various planes through the fruit * show an infolding of the pericarp on the concave side which holds the cup-shaped seed in position. The latter consists of an oily endosperm surrounding the embryo, which lies with its radicle pointing towards the apex of the fruit and the two cotyledons occupying separate slit-like cavities in the endosperm. The drug has no odour; the pericarp is tasteless, but the seed is intensely bitter.

Constituents.—The seed contains a bitter, crystalline, highly-toxic substance, "picrotoxin" which has been given the formula $C_{30}H_{34}O_{13}$, but which may be separated into definite proportions of picrotoxinin, $C_{15}H_{16}O_6 \cdot H_2O$, and picrotin, $C_{15}H_{18}O_7$. The seeds also contain cocculin (a tasteless, crystalline substance), and about 50 per cent. of fat. According to Pelletier and Courbe (1833), the pericarp contains the alkaloids menispermine and paramenispermine.

Uses.—Cocculus indicus is used for the preparation of picrotoxin, which has been employed to a limited extent in phthisis and, in the form of an ointment, to destroy pediculi. Very small quantities are sufficient to stupefy fish.

Order RHEADALES

An order allied to the Ranales, consisting of the families Papaveraceæ (including Fumariaceæ), Capparidaceæ, Cruciferae, and Resedaceæ.

Family PAPAVERACEÆ

A family of 28 genera and about 600 species. The plants are usually herbs with solitary, showy flowers of the floral formula, K_2-3 , C_2+2 or $2+4$, A_∞ , $G(2-\infty)$. The fruit is generally a capsule, with numerous seeds, each containing a small embryo in an oily endosperm. The family may be

* For figures, see Wallis, *Practical Pharmacognosy*, p. 61.

PAPAVERACEÆ

divided into three subfamilies, the Papaveroideæ, Hypecoideæ, and Fumarioideæ.*

The Papaveroideæ, to which the following remarks apply, contains the genera *Papaver* (100 species), *Meconopsis*, *Argemone*, *Eschscholtzia*, *Glaucium*,† and *Sanguinaria*. All the members contain latex tissue. This sometimes accompanies the vascular system, e.g. in *Papaver*, and sometimes is quite independent of it, e.g. in *Sanguinaria*. In some species, e.g. *Sanguinaria* and *Eschscholtzia* the latex is contained in sacs, while in others it is contained in vesicles. In *Papaver* and *Argemone* the latex vessels anastomose when mature and rarely show the remains of the original transverse walls; in *Chelidonium*, however, anastomoses are absent and the marginal parts, at least, of the transverse walls are retained. The poppies are typical members of this subfamily.

Papaver Rhœas, the red, corn or field poppy, is an annual herb about 30 to 60 cm. high. The stem is hairy and bears pinnatifid or pinnatifid leaves, the segments of which are lanceolate and have a deeply serrate margin. The flowers, which appear in summer, are much smaller than those of *P. somniferum*. The petals are scarlet with the exception of a dark violet patch at the base of each. The capsule is glabrous, obovate, and about twice as long as broad. The stigmatic disc has eight to twelve rays. Fresh red poppy petals are used as a colouring agent, usually in the form of a syrup. The chief colouring matter present is an anthocyanidin glucoside, mekocyanin, an isomer of the cyanin found in red rose petals.

PAPAVER SOMNIFERUM

The opium poppy, *Papaver somniferum* Linn. is an annual herb about 50 to 150 cm. in height. The stem and leaves are glaucous. The latter are about 10 cm. in length, entire, sessile, and amplexicaul. The margin is dentate but varies somewhat in the different varieties. The flowers, which are borne on a slightly hairy peduncle, are solitary, nodding in the bud, and have caducous sepals. They have the floral

* The medicinally important genera *Papaver* and *Sanguinaria* belong to the Papaveroideæ. The other subfamilies are of minor interest only to the pharmacist. Neither contains latex vessels or latex cells. In the Fumarioideæ oil-containing sacs are found and interesting alkaloids are found in the tubers of several species of *Corydalis*. For details of these, see Henry's *Plant Alkaloids*.

† *Glaucium flavum* contains the alkaloid glaucine and the three alkaloids found in *Sanguinaria canadensis*.

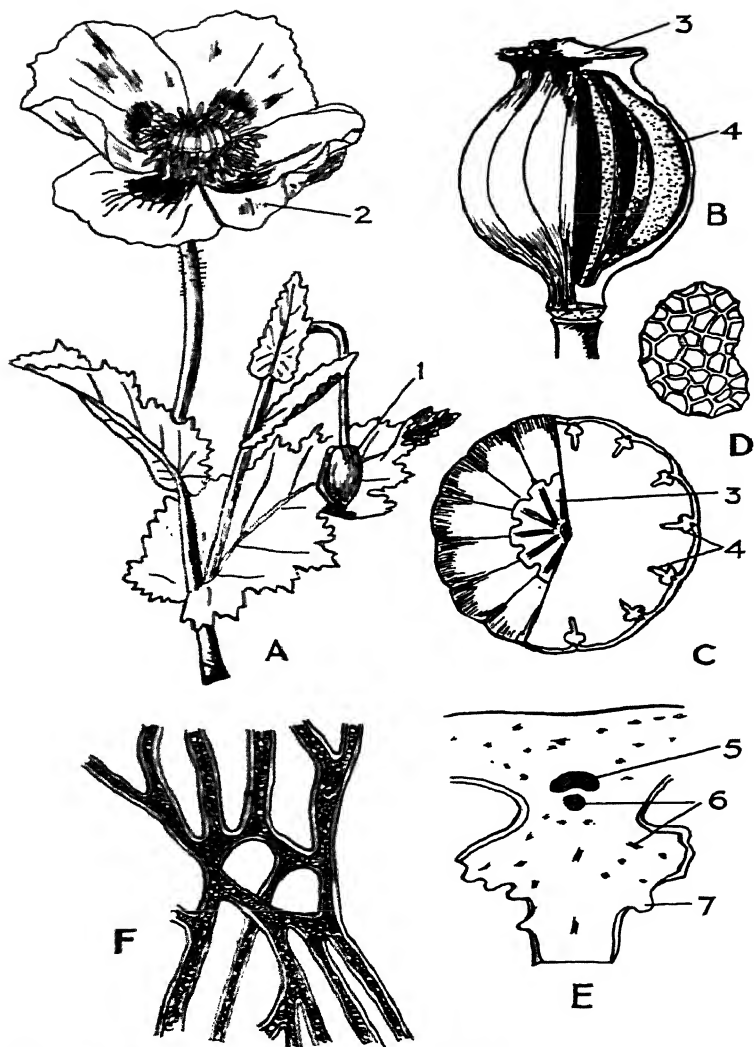


FIG. 124.—*Papaver somniferum*. A, flowering stem; B and C, capsules with pericarp partly removed; D, seed; E, transverse section through part of pericarp and placenta; F, isolated latex vessels. 1, sepal; 2, petal; 3, stigma; 4, placenta; 5, bundle of fibres; 6, vascular bundle; 7, funiculus. (All after Thoms, *Handbuch der Pharmazie*.)

formula $K_2, C_2 + 2, A_\infty, G(\infty)$. The unilocular ovary contains numerous ovules attached to parietal placentas. It bears at its apex a flat disc formed by the union of the radiating stigmas. The capsule opens by means of small valves, which are equal in number to the carpels and situated immediately below the stellate stigma.

In addition to numerous garden hybrids the following varieties are recognised :—

P. somniferum var. *glabrum* Boiss., cultivated in Turkey ; flowers usually purplish but sometimes white ; capsule subglobular, stigmata ten to twelve ; seeds white to dark violet.

P. somniferum var. *album* D.C., cultivated in India and Persia ; flowers and seeds white ; capsules more or less egg-shaped, 4 to 8 cm. in diameter, without pores under the stigma.

P. somniferum var. *nigrum* D.C., cultivated in Europe for the seeds, which are slate-coloured and are known as " maw seeds " (probably a corruption of *mohnsamen*). The leaves and calyx are glabrous, the flowers violet, and the capsules somewhat smaller and more globular than those of the var. *album*.

P. somniferum var. *setigerum* D.C., a truly wild form found in Southern Europe. The peduncles and leaves are covered with bristly hairs. The leaf lobes are sharply pointed and each terminates in a bristle.

Poppy capsules contain, when ripe, from 0.018 to 0.28 per cent. of morphine. They are used as a mild sedative in cough mixtures and as a domestic remedy for toothache. The seeds contain no morphine but about 50 to 60 per cent. of a drying oil which is used by artists and also for cooking.

OPIUM

Opium, B.P. ; *Opium* ; F. *Opium* ; G. *Mohnsaft*

Source.—Opium is the latex, obtained by incision from the unripe capsules of *Papaver somniferum* and dried by spontaneous evaporation. The chief opium producing regions are Turkey in Asia, the Balkans (Turkey in Europe, Yugoslavia, Bulgaria, and Greece), India, Persia, and China.

History.—Opium was well known to the ancients. Dioscorides, about A.D. 77, distinguishes between the latex of the capsules, *opos*, and an extract of the whole plant, *mekonion*. The use of opium spread from Asia Minor to Persia, where opium eating became popular, and thence to

India and China. It was not, however, until the second half of the eighteenth century that opium smoking began to be extensively practised in China and the Far East.

Asia Minor has from very early times been an important centre of opium production. In Macedonia cultivation was started as recently as 1865. Persian opium was imported into this country from about 1870 until after the war, but is now rarely seen. Opium was cultivated in India during the Middle Ages and the monopoly of the Mogul Government was taken over first by the East India Company and then by the British Government. Formerly Indian opiums, being prepared mainly for smoking, were little esteemed for pharmaceutical purposes. That imported since the war is, however, of good quality and is largely used for the manufacture of alkaloids.

Commerce.*—A. Exports.—In pre-war days the production of opium in Turkey averaged 500,000 okes (1 oke=2.82 lb.) per annum. In 1925-26, 228,000 okes were produced. Yugoslavia, the chief Balkan producer, exports about 150,000 kilos annually.

In British India all the opium produced is sold to the Government factory at Ghazipur, United Provinces. The area under cultivation has been reduced gradually and the former large exports to China entirely discontinued since 1913. The extent of the reduction in recent years may be judged from the exports, which fell from about 26 million ounces in 1926-27 to about 9 million ounces in 1930-31.

B. Imports.—The imports into Britain in 1926 were 96,000 lb. from British India; 21,688 lb. from Asiatic Turkey, and 2,398 lb. from other countries. None was imported from Persia or China. In the same year re-exports, chiefly to Russia and the U.S.A., were 20,108 lb.

Cultivation, Collection, and Preparation.—A. Turkey and the Balkans.—In Asiatic Turkey the purple-flowered *P. somniferum* var. *glabrum* is cultivated, while in Macedonia *P. somniferum* var. *album* crossed with a violet-grey form is the principal source.† Rich alluvial soil is preferred and the yield of opium is much increased by the use of fertilisers. Two sowings are usually made, one in the autumn and a second in the spring. The size of the spring sowing is regulated by the success or

* The following statistics are mostly taken from the *C. and D.*, 1928, 494 and 551, where more detailed information will be found.

† Cf. Vrgoč, *Cultivation of Macedonian Opium*, abstract in *Y. B. Pharm.*, 28. 458

otherwise of the first crop which, owing to bad weather or other causes, is often a partial failure. The first crop flowers from the end of May to the beginning of June and the second crop about a fortnight later.

Each plant bears about five to eight capsules. These are incised when they are about 4 cm. in diameter and the colour is changing from green to yellow. The incisions are made between mid-day and evening, the operators working in lines

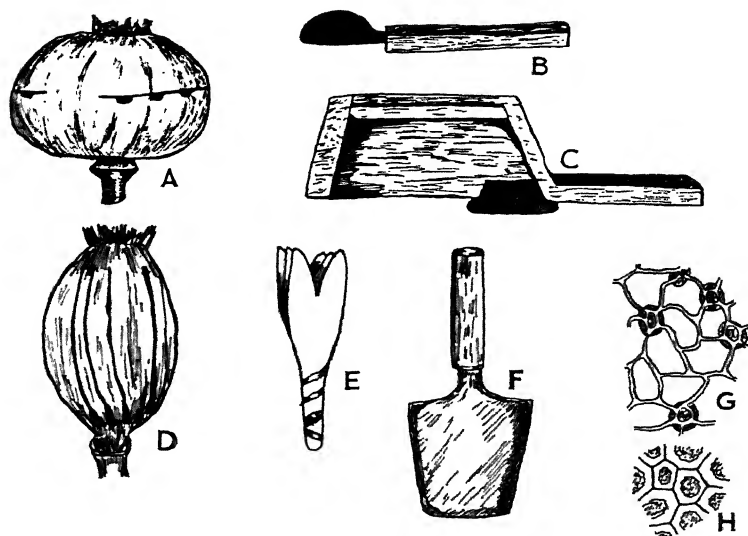


FIG. 125.—Opium. A, incised capsule of Turkish poppy; B, instrument used for incision; C, a scraper used in Turkey; D, incised capsule of Indian poppy; E, "nushtur"; F, "seetooar"; G, epidermis of poppy leaf; H, epidermis of poppy capsule.

and not retracing their steps, to avoid shaking off the exuding latex. For the same reason wind and rain adversely affect the yield. The knives used vary somewhat in shape in different localities as do the number and form of the incisions, but a single transverse cut extending almost completely round the capsule is usual. The incision must not penetrate into the interior of the capsule or latex will be lost. The latex, which is at first white, rapidly coagulates and turns brown. Early in

the morning of the day following the making of the incisions the partly dried latex is scraped off with a knife or special scraper. The latter consists of a piece of metal fitted into a wooden tray provided with a handle (Fig. 125, C). If a knife is used, the scrapings are collected on a poppy leaf. The collectors favour the use of saliva for moistening the knife or scraper to prevent the opium sticking and, subsequently, for massing it into cakes, stating that it prevents mouldiness. The still moist latex is further dried in the air, made into lumps surrounded by poppy leaves and placed in cotton bags containing dry dock fruits (*Rumex* spp.). These are sealed and transported on mules or camels to Smyrna and other ports, where the drug is examined and graded into "firsts," "seconds," and rejected pieces ("chicanti"). The opium of different districts varies enormously in texture and quality, some localities regularly producing opium of the first grade, while others produce that of the second grade. Some produce opium containing about 10 per cent. of morphine when dried ("druggists' " opium), while others produce the "soft" or "shipping" opium and "manufacturing" opium. * Before exportation the opium is repacked in tin-lined cases which are sealed by means of solder, thus giving protection against theft and preventing loss of moisture.

The poppy seeds are pressed to obtain the oil and the seed cake is used as cattle food. These products, according to Virgœ, cover expenses, the opium representing net profit.

B. India.—The plant cultivated in India is *P. somniferum* var. *album*. The incisions are made in the afternoon, from April to October, but instead of an instrument known as a "nushtur" (Fig. 125, C) a narrow iron spike which is drawn down the length of the capsule to produce several longitudinal cuts. The subserotous part of the capsule is done with a trowel. The capsule is cut several times at intervals of two or three days. After collection the latex is placed in a tilted vessel. The dark fluid ("pussewah") which is not required is off. By exposure to air until about

* The districts growing found in and 612

opiums of the different Turkish and Macedonian C. and D., 1928, 493. Maps showing the opium and the Balkans, Persia, and India are to be found in *der Pharmacognosie*, Band III, 1, 599, 607.

October the opium acquires a suitable consistency, which varies with the different varieties (see below), and is ready for packing*.

Varieties.—A. Turkey "Druggists'."—(a) **Old Packing.**—This opium, which is the one described in the Pharmacopœia, contains about 20 per cent. of moisture and not less than 9.5 per cent. of morphine when imported. That produced in the districts of Karahissar, Balukissar, Amasia, Akhissar, Ghiveh, and Boghaditz is usually preferred. It occurs in fairly firm, rounded, or subconical pieces weighing from 250 to 1,000 grammes. The products of different districts vary in the amount and colour of the poppy leaves in which they are wrapped, and in the presence or absence of *Rumex* fruits. Opium is plastic when fresh but hardens on exposure to air. Internally it is more or less granular (distinction from Macedonian, Persian, and Indian opiums). It has a characteristic odour, which assists the expert to judge the quality, and a bitter taste. Druggist's opium is imported in cases weighing 68 to 75 kilograms.

Turkish opium usually contains numerous fragments scraped from the epidermis of the capsules (distinction from Macedonian and Indian opium). The vegetable debris is found in the residue left after exhausting the drug with water, and may be examined in a solution of chloral hydrate. The epidermis of the capsules, which usually comprises the greater part of the vegetable debris, consists of thick-walled, polygonal cells with very occasional stomata. The epidermal cells of the poppy leaves, which are also found, are larger and thinner than those of the capsules, and those fragments from the lower epidermis show numerous stomata (Fig. 125, G and H).† Fragments of *Rumex* fruits and occasional starch grains may also be found.

(b) **Turkish Government Monopoly Opium.**—This form of druggists' opium has been imported since about 1936.‡ It is made by bulking a considerable weight of opium and passing it through some form of mill. The drug is then made into cheese-shaped masses which are uniform in size, weight, and alkaloid content. Each mass (Fig. 126) is about 5 inches

* For details, see Watt's *Dictionary of the Economic Products of India*.

† For figures illustrating the microscopic characters of the leaves and capsules, see Thoms, *Handbuch der Pharmazie*, V, 934-5.

‡ Communication from the Laboratories of Messrs. Stafford Allen & Sons, Ltd., P.J., 1936, June 6, 623.

(13 cm.) in diameter and 3.75 inches (9.5 cm.) thick, and weighs about 4 lb. 6 oz. (2000 G.). The surface is yellowish-brown, being covered with coarsely powdered leaf. It bears on the curved side a paper label in black and gold with the letters IMU inside a star and crescent device. About 40 masses are packed in a tin-lined case and exported from Istanbul. The anhydrous morphine content is usually about 13 per cent.

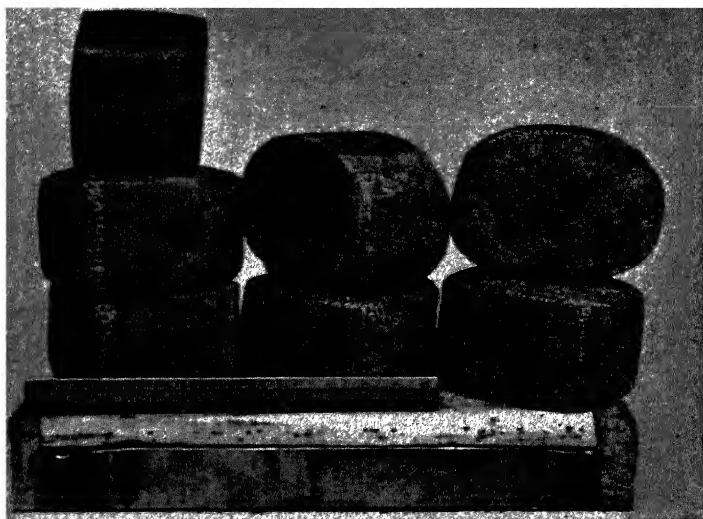


FIG. 126.—Turkish Government Monopoly Opium. The mass at the top on the right shows a hole made in sampling. (Photo Stafford Allen & Sons, Ltd.)

B. "Soft" and "Soft Shipping."—These terms are applied to Turkish and Balkan opiums of pasty consistence, containing some 30 per cent. of moisture and usually a high percentage of morphine. Such opium was formerly exported for smoking to countries where Chinese coolies are employed, and is used for alkaloid manufacture. The Macedonian or Salonica opium, which is mainly produced in Yugoslavia, is favoured by American morphine manufacturers as the American custom

duties make it advisable to import opium of the highest morphine-content available. British alkaloid manufacturers are now favouring Indian opium rather than the Turkish and Macedonian.

C. Indian.—Three kinds of opium are produced at the Ghazipur factory, the only one in British India. They occur in dark brown or blackish, homogeneous, more or less pasty masses :

1. *Excise Opium.*—This is intended for use in India. It is of 90° consistency, *i.e.* contains 10 per cent. of moisture, and is made up in cubical packets of one seer (about 2 lb.), in cases of sixty.

2. *Medical Opium.*—This is used by the Indian Medical Department or is exported to London. It is of 87·50° consistency and is made up in cakes or square blocks wrapped in waxed paper. Each piece weighs 2 lb. and sixty are packed in a case.

3. *Provision Opium.*—Much of this was formerly sent to the Dutch East Indies, etc., for smoking. It is now imported for the manufacture of alkaloids, recent analyses showing up to 13 per cent. of morphine. It occurs in 3½-lb. balls or cakes, packed about forty in a case and is usually of 70° consistency.

D. Persian.—Considerable quantities of Persian opium were imported during the war, but it is now seldom seen. It usually occurs in brick-shaped masses measuring 4 × 7 × 12 cm., weighing about 1 lb., wrapped in red paper and tied with red or yellow string. It is more homogeneous in texture than Turkish opium and, when dry, very hard and tough, possibly owing to the addition of gum during its manufacture.

E. Other Opiums.—Opium is produced on a large scale in China but is not exported. Egypt no longer exports opium, and every effort is made to stop production for local consumption. In addition to the above countries opium has been produced, often only on an experimental scale, in most European countries, the U.S.A., the East Indies, and parts of Africa. Experiments have shown that a hot climate is not essential—opium of excellent quality has been produced in Scotland—but working costs are too high for success on the commercial scale.

Constituents.—Opium contains about twenty-five alkaloids

which appear to be combined to a greater or lesser extent with meconic acid and sulphuric acid.*

The general composition of opium has been given as follows:—†

Morphine, 6 to 15 per cent. (average 8 per cent.).‡

Narcotine, 4 to 8 per cent.

Other alkaloids, 0.5 to 2 per cent.

Meconin, under 1 per cent.

Meconic acid, 3 to 8 per cent. (average 4 per cent.).

Peculiar resin and caoutchouc, 5 to 10 per cent.

Fat, 1 to 4 per cent.

Gum and soluble humoid acid substances, 40 to 56 per cent.

Insoluble matters and mucus, 18 to 20 per cent.

Ash, 4 to 8 per cent.

Water, 8 to 30 per cent. (average 20 per cent.).

The opiums of different countries differ not only in morphine content but in the relative amounts of the other alkaloids, of which the chief are codeine, thebaine, narcotine, narceine, and papaverine. In comparing analyses of different samples it is necessary to know if the figures are calculated on the moist drug, as imported, or the drug dried to constant weight. Further, the morphine content of opium after increasing for a time after collection gradually decreases,§ hence the age of the sample is of importance.

Codeine and narcotine are usually present in greater amounts in the Macedonian, Indian, and Persian opiums than

* According to Dott (1884), the alkaloids are combined with both acids. Meconic acid in Indian opium has been studied by Annett and Bose and an abstract of their paper (*N. B. Pharm.*, 1923, 331) states:—"The meconic acid content of opium varies directly as the total alkaloid content, and it appears sufficient in amount for all the alkaloids to be combined as meconates. The soluble sulphate content of the latex increases as the alkaloidal content diminishes. The sulphate is apparently present in a mineral form and the alkaloids as meconates only, the acid reaction of the opium being due to the dissociation of the meconates of the weak bases, narcotine and papaverine."

† Allen's *Commercial Organic Analysis*, Vol. VII, p. 721.

‡ Van der Wielen (1913) suggested the use of a standard opium containing 12 per cent. morphine; 6 per cent. narcotine; 1 per cent. codeine, and 5 per cent. meconic acid.

§ Abraham and Rae, *P.J.*, 1926, 117, 3 and 32, ascribe the loss to a peroxidase, "opiase," which may be destroyed by heating the moist opium to about 100° for two hours. In a recent report on "Opium Research in India" (*C. and D.*, 1932, Aug. 20, 175) reference is made to breeding experiments which are undertaken with a view to improving the product and the attempts made to find out what causes the loss of morphine on storage and what happens to the morphine lost. The conclusion is reached that there seems little advantage to be gained from attempting to produce a strain of poppies having a very high morphine content since the higher the initial morphine content, the quicker is the loss of morphine, so that the advantage of high initial content is soon lost.

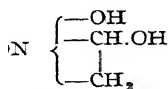
they are in the Turkish, a fact which helps to explain the use of these grades by alkaloid manufacturers. Typical analyses are given below :—

Variety.	Morphine, per cent.	Codeine, per cent.	per cent.
Turkish * ..	9 to 15	0.25 to 1.0	1.5 to 2.0
Macedonian †	13.87	2.1	4.67
Persian † ..	10.69	3.23	11.20
Indian ‡ ..	8.5 to 12.5	1.63 to 1.85	3.6

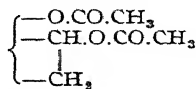
The following table summarises some of the facts about the chief opium alkaloids :—

Alkaloid.	Formula.	Discoverer.	Date	Properties.
Morphine	$C_{17}H_{19}O_3N$	Sertürner	1816	{ Strong bases, which are alkaline to litmus and highly toxic.
Codeine	$C_{18}H_{21}O_3N$	Robiquet	1832	
Thebaine	$C_{19}H_{21}O_3N$	Thiboumery	1835	
Narcotine	$C_{22}H_{23}O_7N$	Derosne	1803	{ Feeble bases, which are but slightly toxic.
Narceine	$C_{28}H_{27}O_8N$	Pelletier	1832	
Papaverine		Merck	1848	

The *morphine* molecule contains a phenolic and an alcoholic hydroxyl group and is readily acetylated, forming *diacetyl morphine* (*heroin*). *Codeine* and *thebaine* are closely related to morphine as may be seen by an inspection of their formulæ :



Morphine

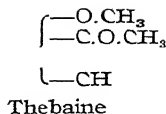
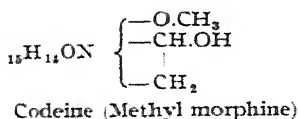


Diacetyl morphine

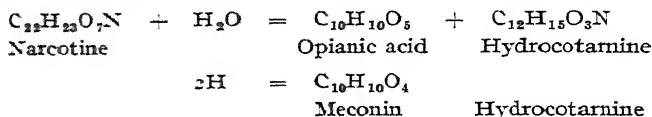
* Hérail, *Traité de Matière Médicale*.

† Jermstad (1922), abstract in *Y. B. Pharm.*, 1923, 20. The narcotine figure for the Persian is exceptionally high. The Macedonian sample contained 7.5 per cent. of water and the Persian 7.99 per cent.

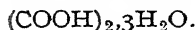
‡ Rakshit, *Analyst*, 1921, 46, 481. This worker, whose experience involves the assay of 3,000 samples a year, states that not a single bag of opium has been received during the past seven years (*i.e.* prior to 1921) which gave less than 7 per cent. of morphine. The bulk of them gave 8.5 to 10.5 per cent., whilst a good quality showed 10.5 to 12.5 per cent.



Narcotine has no narcotic action and is therefore sometimes called *anarcotine*. On hydrolysis it yields *opianic acid* and a base, hydrocotarnine, whilst on reduction it yields hydrocotarnine and *meconin*. The latter substance is normally present in opium.



Meconic acid is a dibasic acid of the formula



It is easily detected, either in the free state or as a meconate by the formation of a deep red colour on the addition of a solution of ferric chloride. As meconic acid is invariably found in opium and in no other drug its presence even in small quantity indicates the presence of opium.

Tests for Opium Alkaloids.—Numerous tests for morphine and codeine salts are given in the Pharmacopœia (*q.v.*). The solubility of morphine in sodium hydroxide solution is explained by its phenolic nature. Codeine, on the other hand, is precipitated by sodium hydroxide.

The following test, due to Denigès (1910), is useful for detecting morphine in galenicals such as syrups:—To 10 ml. of the solution to be tested add 1 ml. of 3 per cent. hydrogen peroxide, 1 ml. of 10 per cent. ammonia and a drop of copper sulphate solution (or stir with a copper wire). If morphine be present a red colour is produced.

Adulteration.—Opium may be adulterated with sugary fruits, gum, powdered poppy capsules and other substances, too numerous to mention. Valuable evidence as to purity may be gained by microscopical examination combined with determinations of moisture content, morphine content and the amounts of water-soluble extractive and ash.

Morphine Unit.—When comparing the price of different samples of opium a unit of 1 per cent. of morphine per lb. is

often used, *e.g.* an opium assaying 11.5 per cent. of morphine and selling at 12s. 6d. per lb. is valued at approximately 1s. 1d. per unit.

Uses.—The alkaloids present in opium in greatest proportion decrease in narcotic properties in the order morphine, codeine, narcotine. Opium and morphine are widely used to relieve pain and are particularly valuable as hypnotics as, unlike many other hypnotics, they act mainly on the sensory nerve cells of the cerebrum. Codeine is a milder sedative than morphine and is useful for allaying coughing. Both morphine and codeine decrease metabolism and the latter, particularly before the introduction of insulin, was used for the treatment of diabetes. Opium, while closely resembling morphine, exerts its action more slowly and is therefore preferable in many cases, *e.g.* in the treatment of diarrhœa. Opium is also used as a diaphoretic.

SANGUINARIÆ RHIZOMA

Sanguinaria ; Bloodroot ; *F. Sanguinaire* ; *G. Blutwurz*

Source.—Bloodroot consists of the dried rhizomes and roots of *Sanguinaria canadensis*, a perennial herb widely distributed in the woods of North America. It should be collected during or immediately after flowering.

Characters.—The drug consists of dark brown, more or less cylindrical pieces of rhizome, from 2 to 7 cm. in length and from 5 to 15 mm. in diameter. Some of the pieces are branched and some show numerous wiry roots. The latter are, however, usually broken off in the commercial drug. The rhizome breaks

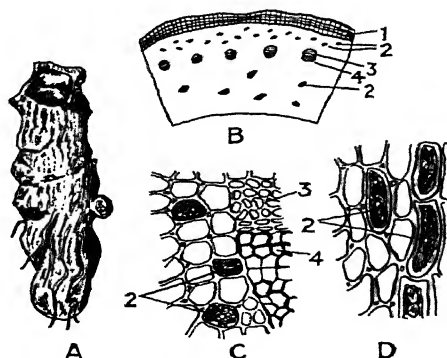


FIG. 127.—*Sanguinaria canadensis*. A, rhizome (natural size); B and C portions of a transverse section of the same; D, a longitudinal section. 1, outer bark; 2, latex cells; 3, phloem; 4, xylem.

with a short fracture and, if not overheated during drying,

shows numerous red dots (secretion cells) distributed throughout the starch-containing parenchyma of the bark and large pith. If dried at too high a temperature the secretion escapes from its containing cells and the whole section assumes a deep red or brownish-red colour. A ring of small, yellow, fibrovascular bundles lies about 1 mm. from the outside. (Odour, slight; taste, acrid and bitter.

Transverse and longitudinal sections examined under the microscope show that the latex cells are scattered or arranged in irregular chains throughout the parenchyma of the inner bark and pith.

Constituents.—Bloodroot contains the alkaloids sanguinarine (Dana, 1829) and chelerythrine (Probst, 1839) with smaller quantities of the alkaloids protopine and β - and γ -homochelidonine. Beringer and Homerberg (1915) found 4.7 to 7.0 per cent. of alkaloids in the rhizomes and about 1.8 per cent. in the roots. Sanguinarine and chelerythrine, although themselves colourless, form red and yellow salts respectively. The drug also contains red resin and starch.

All the above alkaloids have been found in other members of the Papaveraceæ, and like berberine and hydrastine are isoquinoline derivatives. Some of the alkaloids of opium, e.g. narcotine and papaverine, are also isoquinoline derivatives. It will thus be seen that the orders Ranales and Rhœadales contain numerous examples of alkaloids of this type.

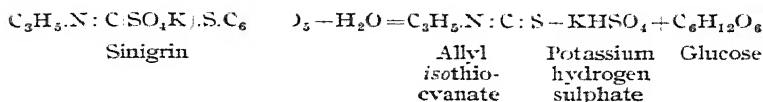
Uses.—Bloodroot is used in atonic dyspepsia and as an expectorant in bronchitis, etc. Large doses affect the heart and produce vomiting.

Family

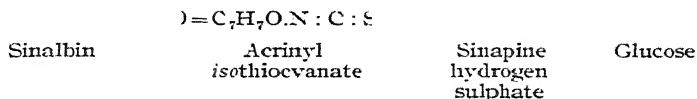
A family of about 200 genera and 2,000 species; usually herbs. The inflorescence is typically a raceme without bracts. The flowers are of the type, K_2+2 , C_2+2 , A_2+4 , $G(2)$. The stamens are tetradynamous and the ovary is divided into two loculi by a replum uniting the two parietal placentas. The fruits are called siliquas when elongated, as in the wall-flower and mustards, or siliculas when almost as broad as long, as in the shepherd's purse and horseradish.

Many members of the family contain glycosides which on hydrolysis yield pungent volatile oils. Black mustard seeds (*Brassica nigra*) and horseradish root (*Cochlearia Armoracia*),

for example, contain the glucoside sinigrin and an enzyme, myrosin, which brings about its decomposition as follows :—



White mustard seeds contain the glucoside sinalbin and myrosin which react yielding a pungent-tasting but almost odourless oil, the pungent principle acrinyl isothiocyanate being much less volatile than allyl isothiocyanate :—



Oils containing similar compounds to the above are obtained from the seeds of *Brassica oleracea*, *B. rapa*, *B. napus*, and *B. juncea*.* *Raphanus sativus* (radish) and *Nasturtium officinale* (watercress) yield mainly phenylethyl isothiocyanate; *Lepidium sativum* (cress), benzyl isothiocyanate; and *Cochlearia officinalis* (scurvy grass) isobutyl isothiocyanate. The seeds of cruciferous weeds are frequently found in samples of linseed and, if present in quantity, may give a pungent odour and taste to moistened linseed meal.

Myrosin cells are widely distributed in the family and may be conveniently studied in the root of the radish. In shape they usually show little difference from the surrounding cells but may be identified by their protein contents, which are coagulated by alcohol and stain red with Millon's reagent.

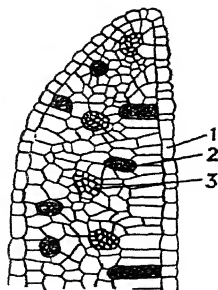


FIG. 128.—Portion of a transverse section of a cotyledon of black mustard. 1, epidermis; 2, myrosin cell; 3, vascular bundle. (After Hérail.)

* The percentages of oil found in twenty-three varieties of *Brassica* and *Raphanus* examined by Grimme (1912) will be found in Parry's *Chemistry of Essential Oils*, p. 496. In addition to the above-mentioned members of the Cruciferae, an oil containing isobutyl isothiocyanate is obtained from the seeds of the nasturtium, *Tropaeolum majus* (Order, Geraniales; Family, Tropaeolaceae).

PHARMACOGNOSY

Fixed oils are obtained from both black and white mustard seeds. Rape or colza oil, which is widely used as a lubricant, is obtained from the seeds of *B. rapa* (*B. campestris*), *B. napus*, and other species of *Brassica*.

Horseradish root, the root of *Cochlearia Armoracia*, which was formerly official in the fresh state, consists of the rootstock and roots. The drug is yellowish or brownish externally and white and fleshy internally. The rootstock, which is about 5 cm. in diameter, bears elongated leaf scars and shows internally a stem structure. The roots vary from 1 to 3 cm. in diameter. In transverse section they show a thick bark which is separated from the wood by a distinct cambium. After staining with phloroglucinol and hydrochloric acid the wood shows isolated groups of vessels, which are especially abundant near the cambium. The root is otherwise unlignified. When scraped a pungent odour and taste is developed.

The root contains sinigrin and myrosin and after crushing and moistening yields about 0.06 per cent. of volatile oil containing allyl isothiocyanate.

Black mustard consists of the seeds of *Brassica nigra*, a small annual cultivated in England and on the Continent. They are globular and from 1 to 1.6 mm. in diameter. The testa is dark reddish-brown and minutely pitted. The cells of the outer epidermis of the testa contain mucilage. The embryo is oily and greenish-yellow or yellow in colour; it consists of two cotyledons folded along their midribs to enclose the radicle (*i.e.* orthoplocal, ∞). Powdered mustard acquires a much brighter yellow colour on treatment with alkali.

Black mustard seeds contain sinigrin and myrosin and yield after maceration with water from 0.7 to 1.3 per cent. of volatile oil. The latter contains over 90 per cent. of allyl isothiocyanate. The seeds also contain about 27 per cent. of fixed oil, 30 per cent. of proteins, mucilage, and traces of sinapine hydrogen sulphate (*cf.* white mustard). Ash, 4.2 to 5.7 per cent.

White mustard, the seeds of *Sinapis alba*, are globular in shape and from 1.5 to 2.5 mm. in diameter. The testa is yellowish and almost smooth, and contains mucilage in its outer epidermal cells. The kernel is oily and the cotyledons are folded as in black mustard. On treatment with water the powder develops a pungent taste but the pungent odour of

the black variety is absent. With alkali the powder acquires a bright yellow colour.

White mustard seeds contain the glucoside sinalbin and

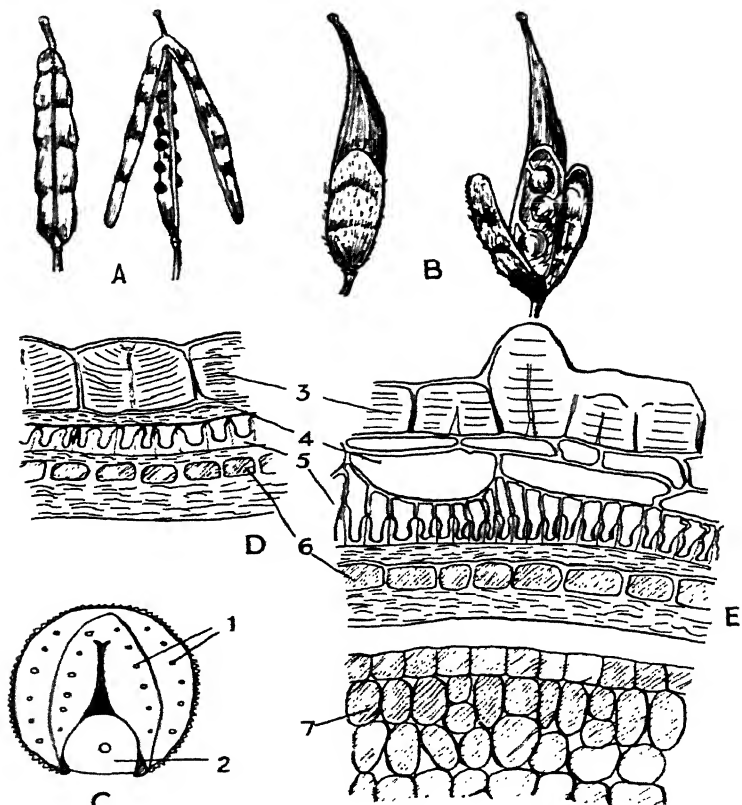


FIG. 129.—A, fruit of black mustard ; B, fruit of white mustard ; C, seed of black mustard in transverse section ; D, section of seed coat of white mustard examined in glycerin ; E, the same with the outer part of a cotyledon after a short boiling in chloral hydrate solution. 1, vascular bundles of cotyledons ; 2, radicle ; 3, mucilage cells ; 4, giant cells ; 5, sclerenchymatous cells ; 6, aleurone layer ; 7, cotyledon. (After Thoms, *Handbuch der Pharmazie*.)

myrosin. In the presence of moisture decomposition takes place with the formation of acrinyl isothiocyanate, sinapine hydrogen sulphate and glucose. Acrinyl isothiocyanate is an oily liquid having a pungent taste and rubefacient properties but, owing to its slight volatility, it lacks the pungent odour of allyl isothiocyanate. Sinapine hydrogen sulphate, which is also found in black mustard, is the salt of an unstable alkaloid. The seeds also contain about 30 per cent. of fixed oil, 25 per cent. of proteins, and mucilage. Ash about 4 per cent.

The mustards are used, particularly in the form of plasters, as rubefacients and counter-irritants. In large doses they have an emetic action. Both varieties are used as condiments.

Order PARIETALES

An order containing ten families, of which the Violaceæ is the one best known in Britain.

Damiana consists of the dried leaves of *Turnera diffusa*, var. *aphrodisiaca* (Fam. Turneraceæ), and probably other species of *Turnera*. The drug is collected in Texas and Mexico. The leaves are yellowish-green to green in colour, broadly lanceolate, shortly petiolate, and 10 to 25 mm. long; margin with 3 to 6 teeth on each side; veins pinnate and prominent on the lower surface. The drug usually contains some of the reddish-brown, cylindrical twigs, flowers, and spherical fruits. *Damiana* has an aromatic odour and taste. It contains 0.5 to 1.0 per cent. of volatile oil; a brown amorphous substance, damianin, resins and gum.

Families **BIXACEÆ** and **FLACOURTIACEÆ**

The family Bixaceæ is now limited to a single species, *Bixa orellana*, the red seeds of which yield the red colouring matter, annatto. The plants described below, although formerly placed in the Bixaceæ, are now regarded as members of the Flacourtiaceæ, a tropical family of about 500 species, most of which are woody.

OLEUM HYDNOCARPI

Oleum Hydnocarpī, B.P. ; Hydnocarpus Oil

Source.—Hydnocarpus oil is a fatty oil obtained by cold expression from the fresh, ripe seeds of *Hydnocarpus Wightiana* Blume.

Characters.—The official substance is a yellowish oil or cream-coloured fat according to the temperature at which it is kept. For the physical and chemical constants, see the Pharmacopœia.

Constituents.—Hydnocarpus oil contains chaulmoogric acid, $C_{18}H_{32}O_2$, hydnocarpic acid, $C_{16}H_{28}O_2$, taraktogenic acid and isogadoleic acid. Chaulmoogric and hydnocarpic acids are dextrorotatory and unsaturated. Both hydnocarpus oil and the ethyl esters of chaulmoogric and hydnocarpic acids are used, with good results, in the treatment of leprosy. The oil is also used for psoriasis and rheumatism.

Allied Drugs.—The oils of *Hydnocarpus anthelmintica* and *Taraktogenos Kurzii* have also been used for leprosy.

Family CANELLACEÆ (WINTERANACEÆ)

A family closely related to the Flacourtiaceæ.

CANELLÆ CORTEX

Canella Bark, White or Wild Cinnamon, False Winter's Bark ; F. Canelle Blanche ; G. Weisser Zimmt

Source.—Canella bark is the dried rossed bark of *Canella Winterana* Linn. (*Canella alba* Murr.), a small tree growing in the Bahama Islands and Florida. The bark is beaten while on the tree to loosen it and to remove the grey cork. After collection, it is dried in the shade.

Characters.—Canella occurs in quills or channelled pieces of very variable size but usually from 1 to 5 cm. in length, 1 to 3 cm. in width, and 2 to 5 mm. in thickness. The outer surface is of a light, orange-brown colour, somewhat scaly, and shows circular or oval depressed scars (Fig. 130). The inner surface is paler in colour and shows a few coarse striations.

PHARMACOGNOSY

Odour. slightly aromatic, very aromatic when burnt; taste, aromatic and somewhat bitter.



FIG. 130.—Bark of *Canella alba* (Sutcliffe).

The bark breaks with a short granular fracture. A prepared transverse section shows isolated patches of cork, a phelloderm of sclerenchymatous cells, a parenchymatous cortex containing oil cells and rosette crystals of calcium oxalate. The wavy medullary rays are white, since each cell contains a rosette crystal of calcium oxalate. Oil cells occur in the phloem but there are no bast fibres.

Constituents.—Canella contains about 0.75 to 1.25 per cent. of volatile oil. An analysis by Frey gave volatile oil 1.28 per cent., resin 8.2 per cent., mannite 8 per cent., ash 8.9 per cent. The oil contains eugenol, cineole, pinene, and caryophyllene.

Uses.—Canella is an ingredient of the familiar remedy, *Hiera Picra* (*Pulvis Aloes et Canellæ* B.P.C.). The negroes use canella as a condiment.

Order CUCURBITALES

An order comprising the families Cucurbitaceæ and Begoniaceæ.

Family CUCURBITACEÆ

Genera about 100; species about 800. Herbs climbing by means of tendrils, *e.g.* *Bryonia*, or prostrate, *e.g.* *Ecballium*. The flowers are generally unisexual, *e.g.* *Bryonia* and *Citrullus*, regular and pentamerous, except in the gynœcium where the carpels are reduced to three. The fruit is of the fleshy type seen in the garden cucumber and colocynth in which the placenta enlarge greatly and become bifid. Seeds numerous and exalbuminous. The straight embryo usually contains fixed oil.

Most members of the family possess bicollateral bundles and certain ones show anomalous root structure. One of the latter is the bryony, *Bryonia dioica*, in which "cambial tissue is formed around individual groups of secondary vessels belonging to the wood of the root; this tissue produces xylem (without vessels) towards the centre, and phloem to the side away from the centre of the group of vessels concerned; hence concentric vascular bundles are formed in the wood."

It is worthy of note that the drugs described below, namely, bryony root, colocynth, and elaterium, are all used as purgatives. Melon pumpkin seeds, which were formerly credited with similar properties, are no longer used.

Bryony root is the root of *Bryonia dioica*, a climbing plant which is common in English hedges. It attains a large size, being frequently 50 cm. long and from 10 to 15 cm. in diameter at the crown. When fresh it has a disagreeable odour and acrid taste. The dried drug is usually in the form of transverse slices which are seldom more than 6 cm. in diameter. They have a thin, greyish cork and whitish wood. The latter is somewhat radiate

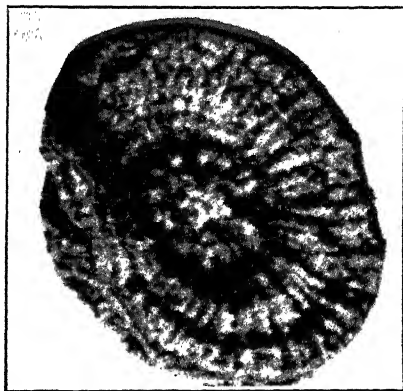


FIG. 131.—Bryony root (Newman).

and shows distinct concentric rings (Fig. 131). As mentioned above, concentric vascular bundles are to be found on microscopical examination.

Bryony root contains purgative principles, the chief of which appears to reside in the dark brown resin, bryoresin. The work of Power and Moore (1911) indicates the presence of an alkaloid and a glycoside. These are said to have no purgative action, but a second glycoside (Jensen, 1915), although non-purgative, acts on the central nervous system.

COLOCYNTHIDIS FRUCTUS

Colocynthis, B.P.; *Colocynth*, *Colocynth Pulp*, *Bitter Apple*;
F. *Fruit de Coloquinte*; G. *Koloquinthen*

Source.—Colocynth is the dried pulp of the fruit of *Citrullus Colocynthis* Schrader, an annual or perennial herb found from India to the West Coast of Africa and from the Equator to Southern Europe. Our supplies are mainly derived from Syria, Cyprus, the Anglo-Egyptian Sudan and North Africa.

Collection and Varieties.—The drug is obtained from both wild and cultivated plants. Flowering takes place from May to August. In the case of "Turkey" colocynth (Syria and Cyprus), which is usually of good quality, the fruits are collected in the autumn when they begin to turn yellow. They are peeled with a knife and dried in the sun or by artificial heat. Egyptian colocynth (Anglo-Egyptian Sudan) is frequently broken and the seeds have been more or less completely removed and the pulp compressed. Spanish colocynth is usually of a darker colour than the above and contains a high proportion of seeds. The unpeeled Mogadore colocynth, at one time commonly seen in pharmacies, is now rarely imported.

History.—Colocynth was well known to the Greeks and Romans, both Dioscorides and Pliny being familiar with it. The drug was equally well known to the Arabian physicians and was produced in Cyprus and Spain during the Middle Ages. It is mentioned in an Anglo-Saxon herbal of the eleventh century.

Characters.—The fruits resemble a small apple in size and shape. The unpeeled Mogadore fruits are covered with a yellowish-brown rind. The peeled fruits are from 4 to 7 cm. in diameter and show occasional small patches of imperfectly removed rind. The drug as imported may consist of whole "apples" or of broken fragments with or without seeds. The pulp is white or pale yellowish-white in colour and very light in weight. It is odourless but has an intensely bitter taste. The seeds, if not removed, number from 200 to 300 in each fruit and form about 70 per cent. of the total weight. The official drug, however, consists of the dried pulp containing not more than 5 per cent. of the seeds and not more than 2 per cent. of the outer, sclerenchymatous part of the pericarp. It is, therefore, convenient to study in turn the rind, the pulp, and the seeds. For powder, see p. 97.

Colocynth rind (Fig. 133, B) in transverse section shows an epidermis the outer tangential and radial walls of which are strongly thickened; a number of rows of collenchyma and

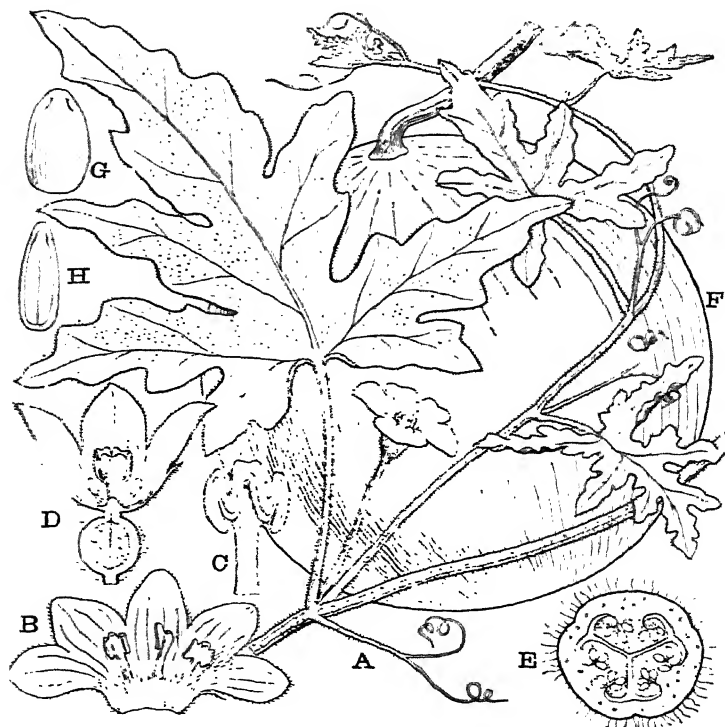


FIG. 132.—*Citrullus Colocynthis*. A, stem bearing a leaf with which are associated a male flower, a lateral branch, and a branch tendril; B, male flower cut open; of the five stamens four are joined in two pairs and one (the central) is distinct; C, one pair of stamens; D, female flower in vertical section; E, ovary in transverse section; F, fruit; G, seed; H, same cut lengthwise. (From Rendle's *Classification of Flowering Plants*.)

parenchyma; and several rows of sclerenchymatous cells. Within these is a parenchymatous zone which passes imperceptibly into the pulp.

Colocynth pulp (Fig. 133, C), which consists very largely of

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the fleshy placenta, is composed of large, thin-walled parenchymatous cells with large intercellular spaces. These cells are

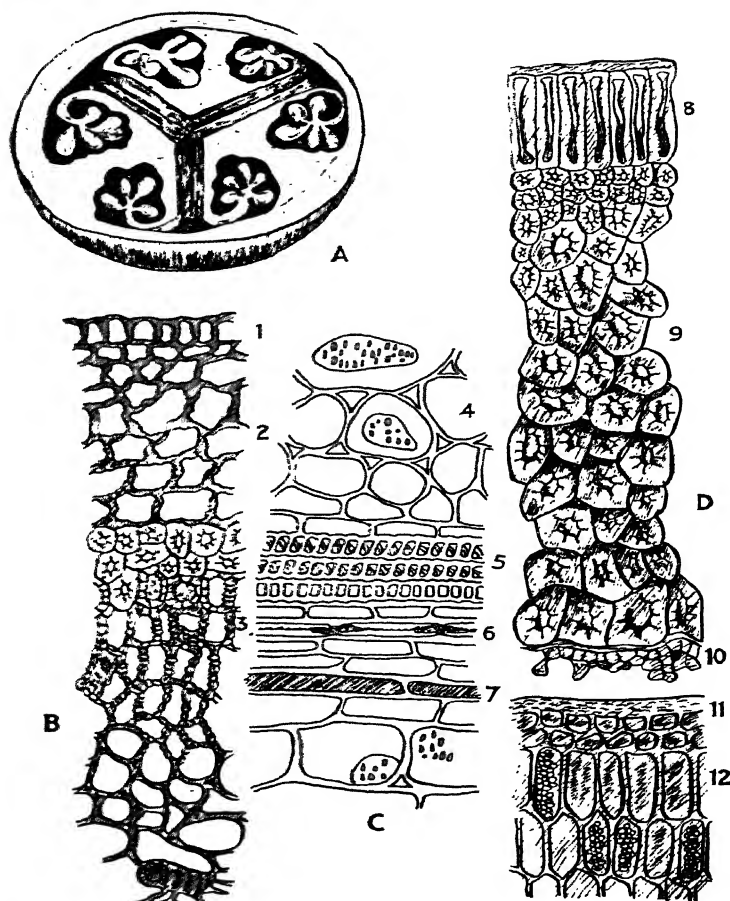


FIG. 133.—*Citrullus Colocynthis*. A, fruit cut transversely; B, transverse section of rind; C, transverse section of pulp; D, transverse section of seed. 1, epicarp; 2, collenchyma; 3, stone cells; 4, parenchyma with pitted walls; 5, xylem elements; 6, phloem; 7, secretory elements; 8, epidermis of seed; 9, stone cells of seed; 10, parenchyma; 11, remains of endosperm; 12, cotyledon. (B and D after J. Moeller, C after Hérail.)

almost devoid of contents and the pulp contains neither starch nor calcium oxalate. In those parts of the cell wall which are common to two cells pitted areas are found. Running through the pith are small, bicollateral bundles with spiral tracheæ. Accompanying the phloem are secretory elements (the idio-blasts of Bræmer), which are said to contain "colocynthin" and which give a red colour with sulphuric acid.

Colocynth seeds (Fig. 132, G and H) are from 6 to 8 mm. in length and of a flattened ovoid shape. They vary in colour from pale yellow (unripe seeds) to dark brown (ripe seeds). The embryo is straight and contains abundant oil and aleurone. There is practically no endosperm. A section through the seed (Fig. 133, D) shows an outer membrane (said to be the innermost region of the pulp) and an epidermis the inner tangential walls of which develop bar-like thickenings as the seed ripens. In immature seeds, which form a high proportion of those usually found, these thickenings are but little developed. Within the epidermis is a many-layered region of sclerenchymatous cells, which increase in size towards the interior; and a narrow zone of reticulated cells and parenchyma. The kernel is bounded by a layer of collapsed cells which with the first layer of parenchyma within it constitute the endosperm. The cotyledons consist of thin-walled cells containing numerous oil globules and aleurone grains about 3 to 5 μ in diameter. Ripe seeds contain no starch and calcium oxalate is absent.

Constituents.—Walz (1858) and other early workers attributed the purgative action of colocynth to a glycoside called "colocynthin." According to Power and Moore (1910), however, the purgative action is due partly to an amorphous alkaloid and partly to an amorphous resin. The former mixed with a crystalline alcohol, citrullol, appears to be the "colocynthin" of earlier workers. The drug also contains the physiologically inactive α -elaterin (see *Elaterium*, p. 396).

The quality of colocynth may be judged by microscopical examination together with determinations of acid-insoluble ash, and the percentage of extractive yielded to solvents. Alcohol (60 per cent.) extractive 20.4 to 31.8 per cent.* The seeds yield from 15 to 17 per cent. of oil to light petroleum, while the pure pulp yields less than 1 per cent. (official limit, 3 per cent.). Commercial samples of colocynth yield about

* Smelt, *Y. B. Pharm.*, 1930, 433.

1 to 6 per cent. of acid-insoluble ash. (B.P. "acid-insoluble ash not more than 8 per cent.").

Uses.—Colocynth is a very powerful hydragogue cathartic. Owing to its griping effect it is rarely prescribed alone. It should always be administered in a finely divided condition.

ELATERIUM

Extractum Elaterii ; *Elaterium* ; *F. Elaterion* ; *G. Elaterium*

Source.—Elaterium is a sediment which is deposited on standing by the juice of the squirting cucumber, *Ecballium Elaterium*. A little is produced in England, but Malta is the chief source of the drug.

History.—Elaterium is still prepared by the method described by Dioscorides. The drug was last official in Britain in the Pharmacopoeia of 1898. Its variable quality has favoured its replacement by "elaterin" (see below), which is official in many pharmacopœias.

Collection and Preparation.—The plant produces oval, hairy fruits about 4 cm. in length. If allowed to ripen the juice and seeds are ejected with great force through an opening in the base. The fruits are therefore collected while unripe, sliced and gently pressed. On standing a sediment is deposited from the juice. This is collected on calico and dried at a low temperature. The yield is very small.

Characters.—Elaterium occurs in small, curved strips of a pale greenish or greyish colour. Marks of the calico on which it has been dried may usually be seen. The fractured surface shows minute crystals. Odour, slight ; taste, bitter and acrid.

Constituents.—By extracting elaterium with boiling alcohol, precipitating with water, and recrystallising the precipitate from alcohol a mixture of crystalline substances, known as "elaterin," is obtained. Good English elaterium yields from 20 to 26 per cent., and Maltese about 14 to 17 per cent. of elaterin.

Power and Moore ‡ from an alcoholic extract of the fresh fruit isolated α -elaterin (*d*-rotatory and physiologically inactive), β -elaterin (*d*-rotatory and purgative), a hydrocarbon, a phytosterol, $C_{27}H_{46}O$, alcohols, fatty acids, and resin. Commercial *elaterin* contains some 60 to 80 per cent. of the inactive α -elaterin, but is a more reliable preparation than elaterium,

* Power and Moore, *Trans. Chem. Soc.*, 1909, 95, 1985.

which is often adulterated with chalk or starch. Elaterium should not yield more than 8 per cent. of ash.

Uses.—Elaterium, like colocynth, is a powerful hydragogue cathartic.

Order GUTTIFERALES

An order of six families including the Ternstroëmiaceæ, Guttiferæ, and Dipterocarpaceæ. In the Ternstroëmiaceæ may be mentioned the genus *Thea*, from the leaves of which tea and caffeine are prepared. The Dipterocarpaceæ includes *Dipterocarpus turbinatus*, the source of gurjun balsam (a copaiba adulterant), and various species of *Shorea*, *Hopea*, and *Balanocarpus*, which yield dammar resin.

Family GUTTIFERÆ

Genera 45 ; species about 900. Usually evergreen shrubs, lianes, or trees. Represented in Britain by the herb St. John's Wort, *Hypericum perforatum*. Schizogenous secretory canals are commonly present in the primary cortex and pith, and sometimes also in the phloem (e.g. *Garcinia*) of the stems. Similar secretory organs occur in the leaves.

CAMBOGIA

Gamboge ; F. *Gomme-gutte de Siam* ; G. *Gummigutt*

Source.—Gamboge is a gum-resin obtained from *Garcinia Hanburii* Hook. f. (*G. morella* var. *pedicellata* Hanbury), a tree 10 to 15 metres in height which is indigenous to Cambodia, Eastern Siam, and Cochin China. The drug is exported from Saigon and Bangkok and passes *via* Singapore to Europe.

Collection and Preparation.—The bark contains secretory ducts in the cortex and phloem which are connected one to another at the nodes ; secretory cavities are also present.* These are filled with a yellow, resinous emulsion. Immediately after the rainy season, *i.e.* from January to May, spiral incisions are made in the bark, 2 to 3 mm. deep and extending from the lower branches to the base of the trunk. The liquid is collected in the internode of a large bamboo. When sufficient has been collected it is poured into smaller bamboos in which it solidifies

* Solereder, p. 124.

in about a month. The bamboos are then heated until they crack, and the gamboge is removed. The drug is bought up by native collectors and sent to Saigon or Bangkok.

Characters.—Gamboge occurs in rolls 15 to 20 cm. long and 3 to 6 cm. in diameter, or in cakes. The former variety, pipe gamboge, is preferred. The surface, which is brownish-orange in colour, is frequently covered with a greenish-yellow powder and bears longitudinal striations formed by contact with the fibres of the bamboo. Gamboge breaks with a conchoidal fracture and shows a dull, waxy interior in which a cavity is sometimes present.

Gamboge is a typical gum-resin and when triturated with water or rubbed with a moistened finger it forms a yellow emulsion. The latter on treatment with ammonia clears and turns orange-red. Lump gamboge is often less pure than the pipe form and its surface frequently shows the impression of the leaves in which it is wrapped.

The purity of the drug may be judged by the fact that it should give no blue colour when treated with solution of iodine, and when treated with chloral hydrate solution (or alternate applications of alcohol and water) it should leave only a few particles of vegetable debris.

Constituents.—Good gamboge contains from 70 to 80 per cent. of resin (cambogic acid) and from 15 to 25 per cent. of water-soluble gum with which is associated an oxydase enzyme. The resin is soluble in organic solvents and alkaline solutions; it has an acrid taste. From it have been isolated α -, β -, and γ -garcinolic acids.

Uses.—Gamboge is employed to a limited extent, and usually in combination with other drugs, as a hydragogue cathartic. It is also used as a pigment.

Order MALVALES

An order consisting of the families Tiliaceæ, Malvaceæ, Bombaceæ, and Sterculiaceæ. Species of *Corchorus* (Tiliaceæ) yield jute (p. 140). Kapok, which consists of the lignified hairs which surround the seeds of certain Indian species of *Bombax* (Bombaceæ), is used in life-belts and as a substitute for non-absorbent cotton wool.

MALVACEÆ

Family MALVACEÆ

A family which consists of about 50 genera and is represented in Britain by the genera *Lavatera*, *Málvæ*, *Althæa*. The marshmallow and cotton plants (p. 129) are typical members of the family.

ALTHÆA RADIX

Marshmallow Root ; F. *Racine de Guimauve* ; G. *Eibischwurzel*

Source.—Marshmallow root is derived from *Althæa officinalis*, a perennial herb which is found wild in moist situations in southern England and Europe. In general appearance it closely resembles the common hollyhock, *Althæa rosea*. The plant has a woody rootstock from which arise numerous roots up to 30 cm. in length. The drug is chiefly collected on the Continent from plants at least two years old. The roots are dug up in the autumn, scraped free from cork and dried, either entire or after slicing.

Characters.—The drug occurs in whitish, fibrous pieces about 15 to 20 cm. long and 1 to 2 cm. in diameter, or in small transverse slices. Odour, slight ; taste, sweetish and mucilaginous.

A transverse section shows a bark about 1 to 2 mm. thick, which is separated by a greyish, sinuate cambium from the white, radiate wood. The section shows numerous mucilage cells the contents of which are coloured a deep yellow by a solution of sodium hydroxide. This test may be applied direct to the root or to an infusion made with cold water.

Constituents.—Marshmallow root contains from 25 to 35 per cent. of mucilage, a similar quantity of starch, pectin, and sugars, and about 2 per cent. of asparagine. The latter, which is the amide of aspartic (aminosuccinic) acid, is also found in asparagus, potatoes, liquorice, etc. It has no therapeutic value.

Uses.—Marshmallow root, and also the leaves, are used as demulcents.

OLEUM GOSSYPII SEMINIS

Oleum Gossypii Seminis, B.P. ; *Cotton Seed Oil* ;
F. *Huile de Semences de Coton* ; G. *Baumwollsaamenöl*

Source.—Cotton seed oil is expressed in America and Europe. In this country Egyptian and Indian cotton seed, which do not require delinting on arrival, are largely used.

Preparation.—The preparation of cotton seed oil is described on p. 36. The process is one of hot expression and a pressure of about 1,500 lb. per sq. in. is used. The crude oil is thick and turbid and is refined in various ways, that known as "winter bleached" being the best of the refined grades.

Characters.—Cotton seed oil is a semi-drying oil and has a fairly high iodine value, namely, 103 to 115. When used to adulterate other oils its presence may be detected by the test described in the Pharmacopœia.

GOSSYPII RADICIS CORTEX

*Cotton Root Bark ; F. Écorce de la Racine de Contonier ;
G. Baumwoll-Wurzelrinde*

Cotton root bark is obtained from various species of *Gossypium*. It occurs in flexible strips up to 30 cm. in length and about 1 mm. in thickness. The outer surface is orange-brown and bears rootlets. The inner surface is light brown and striated. Odour, slight ; taste, acrid and astringent.

Resin cells are found in the phloem. The bark yields about 10 per cent. of purplish resin and a small amount of volatile oil. It has been recommended as a substitute for ergot, but Scott (1911) and Eckler (1920) are agreed that it has only a very slight ergot-like action on the uterus.

Family STERCULIACEÆ

A tropical family of 58 genera and about 660 species. Of medicinal importance are the seeds of *Theobroma Cacao*, the seeds of various species of *Cola*, and the gum obtained from various species of *Sterculia* (see tragacanth adulterants).

THEOBROMATIS SEMINA

*Cocoa Seeds, Cocoa Beans ; F. Semence de Cacao ;
G. Kakaosamen*

Source.—Cocoa seeds are obtained from *Theobroma Cacao*, a tree usually 4 to 6 metres in height. Cocoa is produced in South America (Ecuador, Colombia, Brazil, Venezuela, and Guiana), Central America, the West Indies, West Africa (Nigeria and the Gold Coast), Ceylon, and Java.

History.—Cocoa has long been used in Mexico and was known to Columbus and Cortes. Cocoa butter was prepared as early as 1695.

Collection and Preparation.—Cocoa fruits are 15 to 25 cm. long, and are borne on the trunk as well as on the branches. Collection continues throughout the year, but the largest quantities are obtained in the spring and autumn. The fruits have a thick, coriaceous rind, and whitish pulp in which from forty to fifty seeds are embedded. In different countries the seeds are prepared in different ways, but the following may be taken

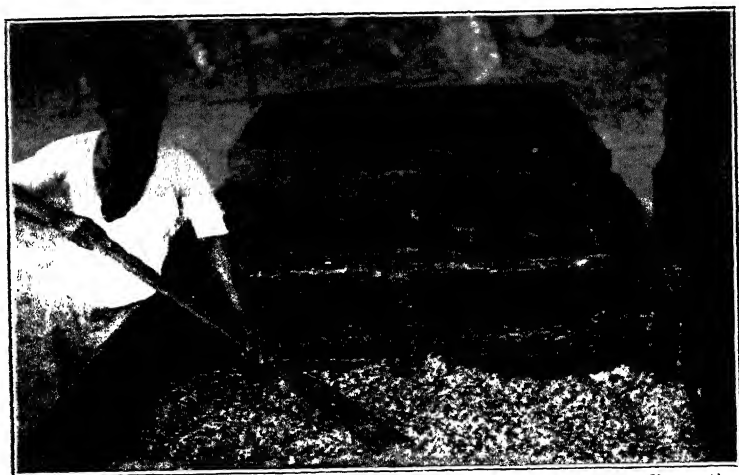


FIG. 134.—Stirring cacao beans in fermenting bins, Gold Coast. (From the Imperial Institute Collection.)

as typical :—The fruits are opened and the seeds, embedded in the whole pulp or roughly separated from it, are allowed to ferment. Fermentation occurs in tubs, boxes, or in cavities in the earth. The process lasts from three to nine days, and the temperature is not allowed to rise above 60°. In Jamaica fermentation is allowed to proceed for three days at a temperature of from 30° to 43°. During this process a liquid drains from the seeds, which change in colour from white or red to purple, and also acquire a different odour and taste. After fermentation the seeds may or may not be washed. They are then

roasted at 100° to 140°, when they lose water and acetic acid, and acquire their characteristic odour and taste. Roasting facilitates removal of the testa. The seeds are cooled as rapidly as possible and the testa removed by a "nibbling" machine. The nibs or kernels are separated from the husk by winnowing. Sometimes the seeds are simply dried in the sun, but these are not esteemed as they have an astringent and bitter taste.

Plain or bitter chocolate is a mixture of ground cocoa nibs with sucrose, cocoa butter and flavouring. Milk chocolate contains in addition milk powder. Although chocolate contains from 40 to 60 per cent. of sugar, the amount of extra cocoa butter added is sufficient to give the product a fat-content of 20 to 40 per cent.

Cocoa powder is obtained by pressing out a portion of the cocoa butter from the roasted and shelled seeds. It usually contains rather more fat than *breakfast cocoa*, which contains not less than 22 per cent.

Macroscopical Characters.—Cocoa seeds are flattened ovoid in shape, 2 to 3 cm. long and 1.5 cm. wide. The thin testa is easily removed from prepared cocoa beans, but is difficult to remove from those which have not been fermented and roasted. The embryo is surrounded by a thin membrane of endosperm. The cotyledons, which form the greater part of the kernel are plano-convex and irregularly folded. Each shows on its plane face three large furrows, which account for the readiness with which the kernel breaks into angular fragments. Both testa and kernel are of a reddish-brown colour, which varies, however, in different commercial varieties and depends on the formation of "cacao-red" * during fermentation and roasting.

Microscopical Characters.—Under the microscope the outer surface of the testa shows the hyphæ of fungi and yeast cells (developed during fermentation) and sometimes earth. Among the microscopical characters of the testa may be mentioned a regular layer of sclerenchymatous cells and very large, mucilage-containing cells. The cotyledons consist mainly of thin-walled parenchyma containing abundant fat, cacao-red and minute starch grains. The detection of husk in powdered cocoa is important. Wasicky (1915) claims that as little as 1 per

* According to Adam, *Analyst*, 1928, 53, 369, cacao-red is a mixture of a catechin, a catechutannin, and a compound of catechin with caffeine.

cent. of husk is detectable by means of a fluorescence microscope. This is confirmed by Gründsteidl (1932).

Constituents.—Cocoa kernels contain 0.9 to 3.0 per cent. of theobromine and the husks 0.14 to 2.98 per cent. of this alkaloid. The seeds also contain 0.05 to 0.36 per cent. of caffeine, cocoa fat or butter (nibs 45 to 53 per cent., husk 4 to 8 per cent.), "cacao-red" (3 to 5 per cent.), sugars (about 2.5 per cent.), and traces of volatile oil.

During the fermentation and roasting much of the theobromine originally present in the kernel passes into the husk. It seems possible that the theobromine is present in the fresh seed as an unstable theobromine-tannin glycoside. According to Schweitzer (1898) the fresh seeds contain a glycoside "cacaonin" * which decomposes during the processes of fermentation and roasting, the alkaloids and "cacao red" being produced at the same time. Although alkaloids may be extracted from unfermented seeds, it is possible that some decomposition takes place during extraction.

Theobromine is produced on the commercial scale from cocoa husks, the annual production of which is estimated at 36,000 tons. The process consists of decocting the husks with water, filtering, precipitating "tannin" with lead acetate, filtering, removing excess of lead and evaporating to dryness. Theobromine is extracted from the residue by means of alcohol and purified by recrystallisation from water.

Theobromine is 3:7-dimethylxanthine, $C_5H_2(CH_3)_2O_2N_4$, the lower homologue of caffeine (trimethylxanthine). It is isomeric with theophylline (1:3-dimethylxanthine), which occurs in small quantities in tea. Theobromine crystallises in white rhombic needles. It gives the murexide reaction (see p. 32), and may be distinguished from caffeine by the fact that it is precipitated from a dilute nitric acid solution by silver nitrate. Theobromine sublimes at 220° , caffeine at 178° to 180° .

Oil of Theobroma may be obtained from the ground nibs by hot expression. The oil is filtered and allowed to set in moulds. Cocoa butter, as it is commonly termed, consists of the glycerides of stearic, palmitic, arachic, oleic, and other acids. These acids are combined with glycerol partly in the usual way as triglycerides and partly as mixed glycerides in which the glycerol is attached to more than one of the acids. It may be

* A similar substance was isolated by Reutter (1913) under the name of "cacaorine."

adulterated with waxes, stearin (e.g. coco-nut stearin), animal tallow, or vegetable tallow (e.g. from seeds of *Bassia longifolia* and *Stellaria schifera*). For the characters and tests for purity of oil of theobroma, see the Pharmacopœia.

Uses.—Cocoa has nutritive, stimulant, and diuretic properties. Theobromine is used as a diuretic. It has less action on the central nervous system than caffeine but is more diuretic. In its isomer theophylline the diuretic effect is even more marked. Oil of theobroma is used in pharmacy chiefly as a suppository base.

Allied Drugs.—**Kola seeds** (*Bissy* or *Gooroo* nuts; F. *Noix de Gourou*, *Café du Soudan*; G. *Kolanuss*). Commercial kola consists of the dried cotyledons of the seeds of various species of *Cola*, trees found in West Africa, the West Indies, Brazil, and Java. The colour of the fresh seeds varies, those of *Cola acuminata* being white or crimson, *C. astrophora* red, *C. alba* white, and *C. vera* (which is possibly a hybrid of the two latter species) either red or white. The dried cotyledons are usually of a dull, reddish-brown colour and more or less broken. They are usually graded as "halves" and "quarters." The whole seeds are 2 to 5 cm. in length and in the seeds usually imported there are two cotyledons. Odourless. Taste, slightly astringent.

Kola seeds contain caffeine (1 to 2.5 per cent.) and a little theobromine, which appear to be partly in the free state and partly combined. According to Knebel (1892), the fresh seeds contain a glycoside, "kolanin," which splits up into caffeine, glucose and "kola-red." Sterilisation of the seeds, although it inhibits the formation of kola red and destroys an enzyme which is present, does not interfere with the liberation of the alkaloid and the presence of a caffeine-tannin glycoside cannot be regarded as proved. Goris and Chevalier (1908) isolated from the fresh seeds a phenolic substance kolatin, which yielded kola-red on oxidation. In 1911 Goris detected a second phenolic substance which he named kolatein.

Guarana (*Pasta Guarana* or *Brazilian cocoa*) is a dried paste prepared mainly from the seeds of *Paullinia Cupana* Kunth (*P. sorbilis* Martius). The seeds are collected from wild or cultivated plants in the upper Amazon basin by members of the Guaranis tribe. The kernels are roughly separated from the shell, broken and made into a paste with water, starch and other substances being frequently added. The paste is then made into suitable shapes and dried in the sun or over fires.

The drug usually occurs in cylindrical rolls 10 to 30 cm. long and 2.5 to 4 cm. in diameter. Portions of broken seed project from the dark chocolate-brown outer surface. When broken, similar fragments project from the fractured surface. The drug has no marked odour but an astringent bitter taste.

Guarana contains 2.5 to 5.0 per cent. of caffeine, "guarana red," and other constituents resembling, as far as is known, those of cola and cocoa. Guarana resembles tea and coffee in its action and the powder grated from the masses is used in South America with water to make a drink.

Coffee consists of the seeds of *Coffea arabica* and other species of *Coffea* (Fam. Rubiaceæ). It contains caffeine (1 to 1.3 per cent.), tannin and chlorogenic or caffeotannic acid (see p. 673), fat, sugars, and pentosans. For a fuller account of coffee, see Allen's *Commercial Organic Analysis*.

Tea consists of the prepared leaves of *Thea sinensis* Linn. (*Camellia Thea* Link.), a shrub belonging to the Ternstroemiaceæ which is cultivated in India, Ceylon, China, and Japan. The leaves contain thease, an enzymic mixture containing an oxydase, which partly converts the phlobatannin into phlobaphene. This oxydase may be destroyed by steaming for thirty seconds. Tea contains from 1 to 5 per cent. of caffeine and from 10 to 24 per cent. of tannin. It also contains small quantities of theobromine, theophylline, and volatile oil.

Maté, the leaves of *Ilex paraguensis* (Fam. Aquifoliaceæ), and *Cassina*, the leaves of *Ilex Cassine*, contain 0.2 to 2.0 per cent. and 1 to 1.65 per cent. of caffeine respectively. For a description of maté, see p. 445.

Order TRICOCCEÆ

An order comprising the Euphorbiaceæ and two other families in which the flowers are usually unisexual and the ovary tricarpeillary and trilocular.

Family EUPHORBIACEÆ

The Euphorbiaceæ consists of about 220 genera and 4,000 species. British representatives belong to the genera *Euphorbia* and *Mercurialis*. Medicinal and other products include castor and croton oils, cascarilla bark, euphorbium, Brazilian arrowroot (which is obtained from the tuberous

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roots of *Manihot utilissima*), kamala (which consists of the glandular hairs of the fruits of *Mallotus philippinensis*), and caoutchouc. Caoutchouc, although obtained from several families, is largely prepared from members of the Euphorbiaceæ, viz. from various species of *Hevea* (Para rubber), *Manihot* (Ceara rubber), and *Sapium*.

Among the anatomical characters of the family may be mentioned the presence of latex cells, e.g. *Euphorbium* and *Ricinus*, latex vessels, e.g. *Hevea*, and secretory cells, e.g. *Croton*. Cork arises in the outermost layer of the primary cortex, and the bark often contains the secretory cells referred to above, e.g. cascarilla bark.

OLEUM RICINI

Oleum Ricini, B.P. ; *Castor Oil*, *Cold Drawn Castor Oil* ;
F. *Huile de Ricin* ; G. *Ricinusöl*

Source.—Castor oil is a fixed oil obtained from the seeds of *Ricinus communis* (Fig. 135). The fruit is a three-celled, thorny capsule. The castor is a native of India, where it is cultivated in large quantities, as well as in South America, various parts of Africa, Manchuria, the Levant, and Italy.* There are about seventeen varieties, which may be roughly grouped into shrubs and trees producing large seeds, and annual herbs producing smaller seeds.

Characters of Seeds.—The seeds show considerable differences in size and colour. They are oval, somewhat compressed, from 8 to 18 mm. long and from 4 to 12 mm. broad. The testa is very smooth, thin, and brittle. The colour may be a more or less uniform grey, brown, or black, or may be variously mottled with brown or black. A small, often yellowish, caruncle is usually present at one end, from which runs the raphe to terminate in a slightly raised chalaza at the opposite end of the seed. The testa is easily removed to disclose the papery remains of the nucellus surrounding a large oily endosperm. Within the latter lies the embryo with two thin, flat, cotyledons and a radicle directed towards the caruncle (Fig. 135, K). Castor seeds, if in good condition, have very little odour ; taste, somewhat acrid.

* The author has before him samples grown in India, Manchuria, Java, East Africa, Kenya, West Africa, Madagascar, Brazil, and Peru. These show great differences in form, size, and colouring.

Preparation and Characters of Oil.—The various processes involved in the preparation of castor oil are described on p. 36. The oil is refined by steaming, filtration, and bleaching. Cold expression yields about 33 per cent. of medicinal oil and further quantities of oil of lower quality may be obtained by other methods.

Medicinal castor oil is a colourless or pale yellow liquid,

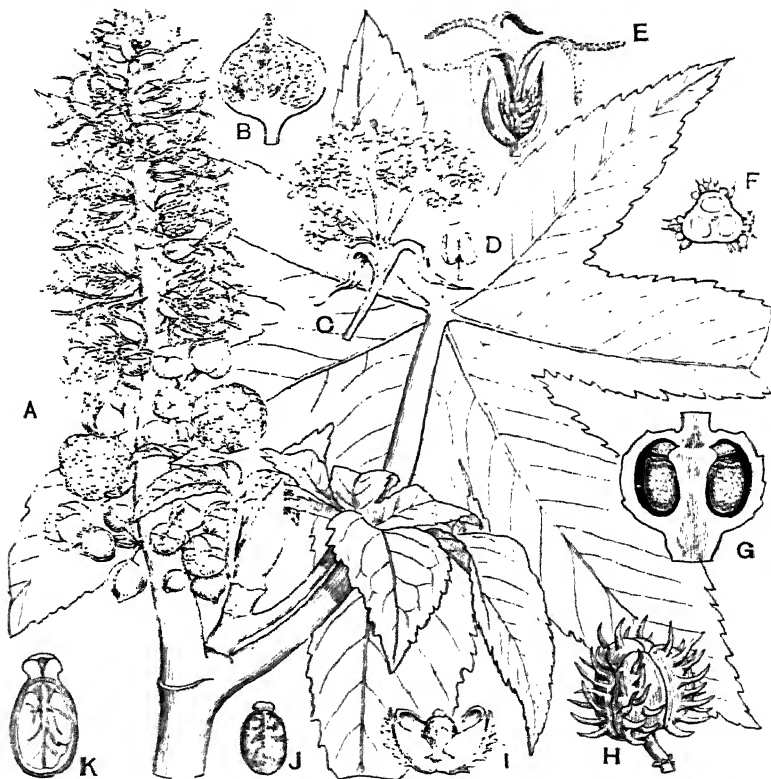
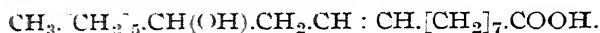


FIG. 135.—*Ricinus communis*. A, upper part of flowering branch, $\times 2$; B, unopened male flower, $\times 2$; C, ditto, open, $\times 2$; D, anther, $\times 10$; E, female flower, $\times 2$; F, ovary cut across, $\times 4$; G, ovary cut lengthwise showing ovules with obturator, $\times 10$; H, capsule, nat. size; I, coccus split open, nat. size; J, seed, nat. size; K, seed cut to show embryo, $\times 1\frac{1}{2}$. (From Rendle and Fawcett's *Flora of Jamaica*.)

with a slight odour and faintly acrid taste. For its chemical and physical constants, see the Pharmacopœia. The acid value increases somewhat with age and an initially high value indicates the use of damaged seeds or careless extraction or storage. Castor oil has an extremely high viscosity.

Constituents.—Castor seeds contain from 46 to 53 per cent. of fixed oil, which consists of the glycerides of ricinoleic, isoricinoleic, stearic, and dihydroxystearic acids. The purgative action of the oil is said to be due to free ricinoleic acid and its stereoisomer, which are produced by hydrolysis in the duodenum. These acids have the formula,



The cake left after expression contains an extremely poisonous toxin known as ricin, which makes it unfit for use as a cattle food. In the body it produces an antitoxin (antiricin) ; it is destroyed by heat. Ricin may be extracted by means of salt solution, precipitated by magnesium sulphate or other electrolyte, and purified by dialysis. The seeds also contain lipases, which under suitable conditions hydrolyse the glycerides and are sometimes employed commercially for the preparation of glycerin from fats and oils. A crystalline alkaloid, ricinine, $\text{C}_{18}\text{H}_{24}\text{O}_2\text{N}_2$, was isolated (Tuson, 1864) and has now been synthesised (Späth and Koller, 1923). It is not markedly toxic.

Uses.—Castor oil is widely used as a purgative. Owing to the presence of ricin, the seeds have a much more violent action than the oil and, although sometimes employed abroad, are not used as a purgative in this country.

Allied Drugs.—*Croton seeds* are obtained from *Croton Tiglium*, a small tree producing similar capsules to those of castor but devoid of spines. The seeds resemble castor seeds in size and shape but have a dull, cinnamon-brown colour and readily lose their caruncles. They contain about 50 per cent. of fixed oil, which contains croton-resin ; also "croton," a mixture of croton-globulin and croton-albumin comparable with ricin. The oil readily produces vesication and, if taken internally, is a violent cathartic. It was official in the 1914 Pharmacopœia. Students testing the seeds are warned to take the smallest possible fragment and to remove it from the mouth after about thirty seconds. At first only a mild, oily taste is noticed, but considerable pain will be suffered if this warning is disregarded.

Physic Nuts or *Purging Nuts* are the seeds of *Jatropha*

Curcas, another member of the Euphorbiaceæ. The seeds are black, oval, and 15 to 20 mm. in length. They contain about 40 per cent. of fixed oil and a substance comparable with ricin called curcin. Both seeds and oil are powerful purgatives.

CASCARILLÆ CORTEX

Cascarilla ; *Cascarilla Bark* ; *F. Cascarille* ; *G. Cascarillrinde*

Source.—Cascarilla is the dried bark of *Croton Eleuteria*, a shrub or small tree found in certain of the Bahama Islands (Andros, Long, and Eleutheria Islands). It is exported from Nassau in bags or cases.

Characters.—Cascarilla occurs in single quills or channelled pieces, 2 to 5 cm. in length, 0.5 to 1 cm. in breadth, and 0.5 to 2 mm. in thickness. Also in very small pieces, the so-called siftings, which appear as if shaved from the plant with a knife. The outer surface has a greyish-white cork and frequently bears the black apothecia of a lichen. The surface is wrinkled and furrowed and tends to exfoliate and expose the cortex. The inner surface is of a dark, chocolate colour and striated. Cascarilla has a bitter taste and an aromatic odour. On burning the odour is more pronounced.

A transverse section shows a very characteristic cork, the outer walls of which are strongly thickened, while the inner walls have numerous small crystals of calcium oxalate embedded in them. The dark brown cortex and phloem consist very largely of parenchyma containing minute starch grains and occasional rosettes or prisms of calcium oxalate. The bark also contains oil cells, secretion tubes containing a resinous latex, and a very few bast fibres.

Constituents.—Cascarilla contains 1.5 to 3 per cent. of volatile oil, a bitter principle called cascarillin, about 15 per cent. of resin, colouring matter and alkaloids (betaine and cascarilline).

The larger pieces of bark yield about 7.5 to 10 per cent. of ash, but "siftings," which contain a higher proportion of the calcium oxalate-containing cork, often yield about 12 per cent. of ash.

Uses.—Cascarilla is used in fumigants and, to a limited extent, as an aromatic and tonic. It was official in the 1914 Pharmacopœia.

EUPHORBIIUM

Euphorbium ; *F. Euphorbe*, *Resine d'Euphorbe* ;
G. Euphorbiumharz

Source.—Euphorbium is a dried, resinous latex obtained from *Euphorbia resinifera*, a cactus-like plant about 2 metres high which is abundant in Morocco. The quadrangular stem

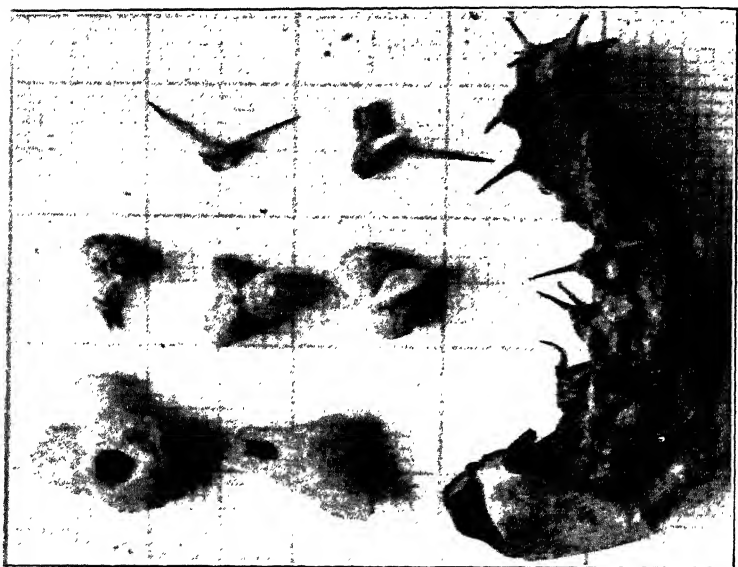


FIG. —Euphorbium. On left, fragments of commercial drug, namely, stipules, inflorescence, fruits, and fragments of resin showing holes left by the stipules. On right, a dried stem obtained from the Scarborough Herb Garden (Newman).

is green in the upper part but brown below. The leaves, which develop along the angles of the stem, are represented only by thorny stipules. The peculiar inflorescence (cyathium) consists of a pistillate flower surrounded by a number of staminate ones (cf. our indigenous spurge). It may easily be mistaken for a single flower. The fruits are tricarpeal. The cortical parenchyma and pith contain long branched latex cells.

Collection.—Euphorbium is collected by the Arabs, who make numerous incisions in the stem. The flow from these is particularly abundant in the rainy season. The white, viscous latex solidifies on the plant or falls to the ground. In the autumn the dried, resinous masses are collected, conveyed to the town of Morocco and thence to the port of Mogadore. Owing to the very acrid nature of the drug it is necessary for all who handle it in quantity to protect their mouths and nostrils with cloths or masks.

Characters.—The secretion occurs in dull, light brown tears, usually about the size of a pea, but irregular in outline and often enclosing portions of stipules, inflorescences, and fruits. These parts of the plant are also found loose in the drug (see Fig. 136) in considerable quantities. Some samples contain much earth. Euphorbium readily breaks to produce a very acrid, sternutatory powder. It is partially soluble in water, alcohol, and ether.

Euphorbium may be identified by making a light petroleum extract and pouring this on the surface of 20 ml. of sulphuric acid containing 1 drop of nitric acid. A blood-red colour is developed at the junction of the two liquids.

Constituents.—The constituents of euphorbium are imperfectly known as attempts to isolate the acrid principle in a pure state have been unsuccessful. It contains about 40 per cent. of "euphorbone," a crystalline fraction from which an alcohol, euphorbol, has been isolated. Also, about 20 per cent. of amorphous euphorbo-resene, 0.7 per cent. of euphorbic acid, mucilage, and about 25 per cent. of calcium malate.

Uses.—Euphorbium is used in veterinary practice as a vesicant and is an ingredient of some antifoul paints for ships' bottoms.

Order GERANIALES

An order allied to the Malvales which includes the Geraniaceæ, Linaceæ, Erythroxylaceæ, Zygophyllaceæ, and a number of other families.

Family

A family of 9 genera and 150 species, of which 90 belong to the genus *Linum*. The fruit is usually a septicidal capsule, containing a number of endospermous seeds.

LINI SEMINA

Linum, B.P.; *Linseed*, *Flaxseed*; F. *Semence de Lin*;
G. *Leinsamen*

Source.—Linseed is the dried ripe seed of *Linum usitatissimum*, an annual herb about 2 feet high with blue flowers and a globular capsule. The flax has long been cultivated for its pericyclic fibres (see p. 142) and seeds. Supplies of the latter are derived from South America, India, U.S.A., and Canada.

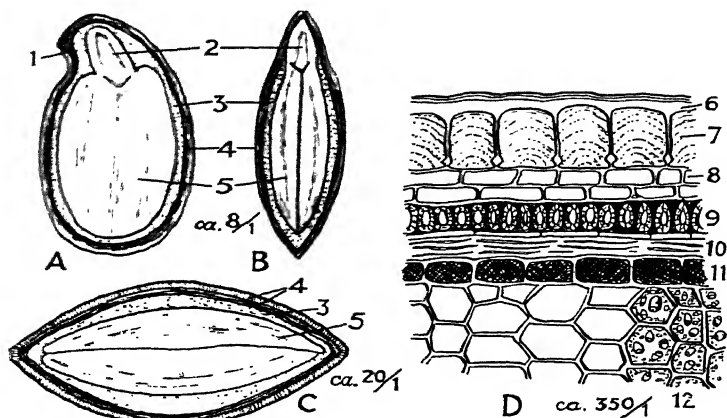


FIG. 137.—Linseed. A, longitudinal section parallel to the broad side of the seed; B, longitudinal section parallel to the narrow side; C, transverse section; D, portion of transverse section. 1, hilum; 2, root; 3, endosperm; 4, seed coats; 5, cotyledon; 6, cuticle; 7, mucilage; 8, thin-walled parenchyma; 9, stone cell layer; 10, hyaline layer; 11, pigment layer; 12, endosperm cells containing aleurone and oil. (After Gilg.)

Large quantities of oil are expressed in England, particularly at Hull, and on the Continent.

Macroscopical Characters.—The seeds are ovate, flattened and obliquely pointed at one end; about 4 to 6 mm. long and 2 to 2.5 mm. broad. The testa is brown, glossy, and finely pitted. Odourless; taste, mucilaginous, and oily. If cruciferous seeds are present, a pungent odour and taste may develop on crushing and moistening. A transverse section shows a narrow endosperm and two large, plano-convex cotyledons.

Microscopical Characters.—Microscopical examination of the testa shows a mucilage-containing outer epidermis, thin-walled parenchyma, a layer of pitted sclerenchymatous cells, and a layer of pigment cells with reddish-brown contents. In the endosperm and cotyledons are numerous aleurone grains and globules of oil. For powder see p. 98.

Constituents.—Linseed contains about 30 to 40 per cent. of fixed oil (note the official requirement for Crushed Linseed), 6 per cent. of mucilage, 25 per cent. of protein, and small quantities of a cyanogenetic glucoside, linamarin. It yields not more than 5 per cent. of ash. Starch is present in unripe seeds, but not in ripe ones.

Linseed Oil.—The extraction of linseed oil resembles that of cottonseed oil, which is described in Chapter III. Only one rolling of the seeds is necessary, after which the meal is heated and pressed.

Linseed oil is a yellowish-brown drying oil with a characteristic odour. On exposure to air it gradually thickens and forms a hard varnish. It has a high iodine value as it contains considerable quantities of the glycerides of unsaturated acids, e.g. linolic acid, $C_{17}H_{31}.COOH$ (about 15 per cent.), and linolenic (about 15 per cent.) and isolinolenic acids, $C_{17}H_{29}.COOH$ (about 65 per cent.), in addition to those of saturated acids such as myristic, stearic, and palmitic.

For use in paint linseed oil is boiled with "driers" such as litharge which, by forming metallic salts, cause the oil to dry more rapidly. Such "boiled oils" must not be used for medicinal purposes. Adulteration with resin, resin oils, cottonseed, sesame, and arachis oils may be detected by the Pharmacopœial tests (*q.v.*).

Uses.—Crushed linseed is used in the form of a poultice. The whole seeds are employed to make demulcent preparations. The oil is used in liniments, paints, the manufacture of linoleum, etc. Linseed cake, which still contains some oil in addition to the proteins and mucilage, is a valuable cattle food.

Family **ERYTHROXYLACEÆ**

A small family often included under the Linaceæ. In the most important genus, *Erythroxylon*, there are about 190 species.

COCÆ FOLIA

Coca ; *Coca Leaves* ; *F. Feuilles de Coca* ; *G. Cocablätter*

Source.—Coca leaves are derived from species of *Erythroxylon* cultivated in Bolivia, Peru, Java, and Ceylon. The chief commercial varieties are Huanuco or Bolivian, Truxillo or Peruvian, and Javanese.

Owing to the long and widespread cultivation of coca there has been some difficulty as to the number of species or varieties yielding the commercial drug and what one botanist has considered as a distinct species another has regarded as a variety. It is now usually considered that the Huanuco leaves are derived from *Erythroxylon Coca* Lamarck, a shrub 1 to 2 metres high, and that the Truxillo and Javanese leaves are those of *Erythroxylon novogranatense* Hieronymus, a shrub 1 to 3 metres high.*

History.—Coca leaves have been used in South America as a masticatory from very early times. They were formerly reserved for the sole use of the native chiefs and Incas. Coca was introduced into Europe about 1688. Cocaine was isolated in 1860.

Collection.—In Bolivia and Peru coca is cultivated at an altitude of 1,500 to 6,000 feet. The cultivated plants are usually pruned so as not to exceed 6 feet in height. Three harvests are collected annually, the first from the pruned twigs, the second in June and the third in November. The leaves are dried in the sun or by artificial heat and are packed in bags.

Macroscopical Characters.—(a) *Huanuco* or *Bolivian coca* leaves are shortly petiolate, oval, 2.5 to 7.5 cm. long and 1.5 to 4 cm. wide. The lamina is greenish-brown to brown and glabrous; margin entire. The midrib is prominent on the lower surface, bears a ridge on its upper surface, and projects slightly beyond the lamina as an apiculus. The latter is often broken in the commercial drug but the leaves are otherwise fairly entire. The lower surface shows two, very characteristic curved lines, one on either side of the midrib. Odour, characteristic; taste, at first bitter and slightly aromatic, the

* Thoms, *Handbuch der Pharmazie*, 1931, p. 1220, gives the following synonyms for these species:—*Erythroxylon Coca* Lamarck (*E. peruvianum* Prescott, *E. bolivianum* Burck), and *Erythroxylon novogranatense* Hieronymus (*E. mexicanum* E. Regel, *E. Coca* Lam. var. *novogranatense* Morris, *E. Coca* Lam. var. *Spruceanum* Burck, *E. truxillense* Rusby).

alkaloids afterwards causing numbness of the tongue and lips.

(b) *Truxillo* or *Peruvian coca* leaves are pale green in colour, more papery in texture than the Huanuco, and are usually broken. Lamina about 1.6 to 5 cm. long; lines on the lower surface usually indistinct. Flowers of a species of *Inga* (Family Leguminosæ, subfamily Mimosoideæ) are sometimes added to the leaves.

(c) *Javanese coca* is not usually seen in this country. The leaves are of the *Truxillo*-type. Large quantities, in the form of coarse powder, are exported to the Continent and Japan for the manufacture of cocaine.

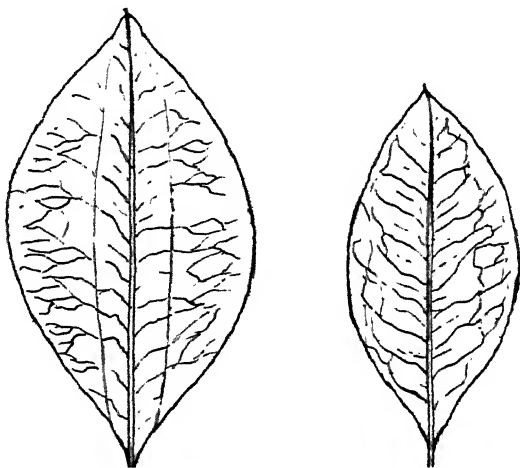


FIG. 138.—Bolivian and Peruvian coca leaves.

Microscopical Characters.—A transverse section of a coca leaf shows upper epidermis, palisade parenchyma containing prisms of calcium oxalate, spongy parenchyma, and a very characteristic lower papillose epidermis with numerous stomata. The midrib is partly surrounded by an arc of pericyclic fibres, above and below which is a considerable amount of collenchyma. A surface preparation of the lower epidermis shows the papillæ as well marked circles, and numerous stomata each

PHARMACOGNOSY

with four subsidiary cells two of which have their long axes parallel to the pore.

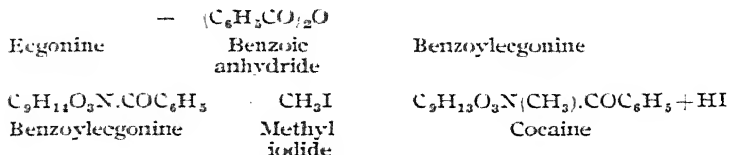
Constituents.—Coca leaves contain about 0.7 to 1.5 per cent. of total alkaloids, of which cocaine, cinnamyl-cocaine, and α -truxilline are the most important. They occur in different proportions in different commercial varieties. Javanese leaves are usually richest in total alkaloids, of which the chief is cinnamyl-cocaine, while the Bolivian, Peruvian, and Ceylon leaves contain less total alkaloid but a higher proportion of cocaine. Other substances isolated from the leaves are :—The relatively simple alkaloids known as hygrines (from Peruvian leaves), the alkaloid tropacocaine (from Javanese and Peruvian leaves), four yellow crystalline glycosides (from Javanese leaves), and cocatannic acid.

Manufacture of Cocaine.—The crude alkaloids may be extracted with dilute sulphuric acid or by treatment with lime and petroleum or other organic solvent. Non-alkaloidal matter is roughly separated by transferring the alkaloids from one solvent to another. The crude alkaloids are obtained in solid form either as free bases by precipitation with alkali, or as hydrochlorides by concentrating an acidified solution. In the case of South American leaves containing a high proportion of cocaine much of this can be crystallised out. Crude alkaloids are largely prepared at Callao.

In Europe pure cocaine is prepared from Javanese leaves, the crude bases, or the crude hydrochlorides. The process depends on the fact that cocaine, cinnamyl-cocaine, and α -truxilline are closely related derivatives of ecgonine, which is produced by hydrolysing them with boiling dilute hydrochloric acid.

Cocaine	→ Ecgonine + Methyl alcohol + Benzoic acid
Cinnamyl-cocaine	→ Ecgonine + Methyl alcohol + Cinnamic acid
	+ Methyl alcohol + α -Truxillic acid

The ecgonine hydrochloride is purified and converted into the free base. This is benzoylated by interaction with benzoic anhydride and the benzoylecgonine purified. The benzoylecgonine is methylated, with methyl iodide and sodium methoxide in methyl alcohol solution, to give methylbenzoylecgonine or cocaine. The latter is converted into the hydrochloride and purified by recrystallisation.



Note the official tests for cocaine, and the tests for absence of the other alkaloids.

Uses.—Cocaine and its salts are widely used as local anæsthetics. Preparations of the leaves are sometimes used as a tonic in neurasthenia.

Family ZYGOPHYLLACEÆ

A family consisting of about 25 genera and 160 species of herbs, shrubs, and small trees.

GUAIACI RESINA

Guaiacum ; *Guaiacum Resin* ; F. *Résine de Guaiac* ;
G. *Guajakharz*

Source.—Guaiacum resin is obtained from the heartwood of *Guaiacum officinale* and *G. sanctum*, small evergreen trees found in the dry coastal regions of tropical America. *Guaiacum officinale* is found on the coast of Venezuela and Colombia and in the West Indies, while *G. sanctum* occurs in Cuba, Haiti, the Bahamas, and Florida.

History.—Guaiacum wood was known in Europe in the sixteenth century, when it was much recommended as a cure for syphilis. The resin was introduced into the London Pharmacopœia of 1677. Both wood and resin were official in the 1914 Pharmacopœia.

Collection and Character of Wood.—The trees are felled and freed from bark. Much of the wood is exported for making mallets, pulleys, scrapers for runner mills, etc., for which it is eminently suitable on account of its durable nature. If the head of a good quality wooden mallet is examined it will be usually found to consist of guaiacum (*lignum vitæ*), the central portion consisting of greenish heartwood and the outer part of yellowish sapwood.

The wood consists of wood fibres and large vessels, the latter often extending from one medullary ray to the next.

All the elements of the heartwood contain resin and those of the sapwood are rich in saponins (guaiacsaponic acid and guaiac-saponin). Commercial guaiacum chips usually consist of both heartwood and sapwood.

Preparation of Resin.—Guaiacum resin may be prepared by the following methods :—(a) A log is bored longitudinally with an auger and then heated in a sloping position so that the resin melts and runs out ; (b) guaiacum wood chips are boiled in salt solution or sea water, when the resin, which melts at about 85° to 90° , may be more or less completely separated from the wood ; (c) the chips are extracted with



FIG. 39.—Splitting a cake of guaiacum resin for inspection, P.L.A.
(*Chemist and Druggist*).

and the resin precipitated by pouring into water, dried, and melted.

It appears doubtful if any resin is obtained from incisions made in the trunk and most of the lump guaiacum of commerce is to be made by the second method described above.

Characters.—Guaiacum resin occurs in large blocks (see fig. 139), or rounded tears about 2 to 3 cm. in diameter. The freshly fractured surface is brown and glassy. The powder is greyish but becomes green on exposure. Taste, somewhat bitter ; odour, when warmed, aromatic. When free from debris guaiacum is soluble in alcohol, chloroform, and solutions of alkalis. An alcoholic solution gives a deep blue

colour (guaiac-blue) on the addition of oxidising agents such as ferric chloride. This colour is destroyed by reducing agents. Colophony, the most likely adulterant, may be detected by the cupric acetate test.

Constituents.—According to Lückér (1864) guaiacum consists of α - and β -guaiaconic acids (about 70 per cent.), guaiaretic acid (about 11 per cent.), and guaiac- β -resin (about 15 per cent.).

Uses.—Guaiacum is used as a local stimulant in the form of lozenges and internally for gout and rheumatism. It is purgative in large doses.

For use as a reagent the resin extracted from the wood by means of chloroform is said to be the most sensitive. An alcoholic solution is used for the detection of blood stains, cyanogenetic glycosides, and oxydase enzymes.

Order RUTALES

The Rutales and Geraniales are closely allied orders, the chief difference being that in the Rutales the plants are mostly shrubs or trees. The flowers have a disc between the andrœcium and gynœcium. Oil glands are of general occurrence. The order includes the families Rutaceæ, Simarubaceæ, and Burseraceæ.

Family RUTACEÆ

The Rutaceæ consists of 120 genera and about 900 species. The members are mainly trees and shrubs, which are widely distributed in temperate and subtropical countries and are particularly abundant in South Africa and Australia. The following subfamilies and species are of medicinal interest:—

Subfamily Rutoideæ.—*Ruta graveolens* (French oil of rue), *Ruta montana*, and *R. bracteosa* (Algerian oil of rue); *Xanthoxylum* and *Fagara* spp. (prickly ash bark); *Xanthoxylum piperitum* (Japan pepper); *Esenbeckia febrifuga* (Brazilian Angostura bark), *Galipea officinalis* (Cusparia or Angostura bark).

Subfamily Toddalioidæ.—*Toddalia aculeata* (Toddalia root bark).

Subfamily Aurantioideæ.—*Citrus Aurantium* (orange peel and its oil, oil of neroli and orange-flower water, oil of petit-grain); *Citrus Limonia* (lemon peel, oil, and juice); *Citrus*

limetta (Italian lime oil and juice); *Citrus medica* var. *acida* (West Indian lime oil and juice); *C. medica* var. *vulgaris* (oil of citron); *C. Bergamoti* (oil of Bergamot); *C. grandis* (oil of shaddock); *C. paradisi* (grape fruit); *Egle Marmelos* (bael fruit).

The oil glands are usually of schizolysigenous origin. In species of *Barosma*, *Citrus*, and *Ruta* the oil cavities develop from a special mother-cell. This cell divides repeatedly and the daughter cells separate from one another schizogenously, leaving a central cavity. The walls of the cells surrounding the cavity break down, forming an oily secretion, and the cavity continues to increase in size lysigenously. The oil glands of the Burseraceæ are also of schizolysigenous origin.

In the leaves of species of *Barosma*, *Empleurum*, and *Toddalia* gelatinisation of the inner membrane of the epidermal cells occurs. The stomata are usually without special subsidiary cells. Clothing hairs of various kinds (peltate, stellate, etc.) occur; also, unicellular or multicellular glandular hairs. Calcium oxalate in prismatic or cluster crystals, or occasionally in raphides and styloids, is found. Diosmin and hesperidin (see below) occur in feather-like crystal aggregates or sphæro-crystalline masses in many species.

The most characteristic constituents of the Rutaceæ are the volatile oils and the rhamno-glucosides, hesperidin, and diosmin. Alkaloids are found in *Jaborandi* leaves, *Angostura* bark and in the seeds of *Peganum Harmala*. The fruit pulp of many of the Aurantioideæ is rich in citric and other acids.

Hesperidin.—Many plants of the Rutaceæ, Leguminosæ, Violaceæ, Polygonaceæ, Globulariaceæ, Myrtaceæ, Santalaceæ, Capparidaceæ, and Solanaceæ have been reported to contain "hesperidin." Generally speaking any sphæro-crystals which were insoluble in organic solvents but soluble in dilute potassium hydroxide solution with production of a yellow colour were assumed to be identical with the hesperidin (citrus-hesperidin) which had been isolated from bitter oranges by E. Hoffman in 1876. In 1883 Borodin examined 3,000 plants and found hesperidin in 150 and pseudohesperidin in 50 of them. He distinguished hesperidin and pseudohesperidin by their different solubilities in ammonia solution, the sphæro-crystals (deposited in the cells by alcohol) of pseudohesperidin being soluble and those of hesperidin almost insoluble.

Citrus-hesperidin has been proved to be a glycoside yielding

glucose, rhamnose, and hesperetin on hydrolysis. Hesperetin is a ketone which yields diosmetin (see below) by ring closure.

Diosmin, reported in many plants as hesperidin, is in fact a closely related rhamno-glucoside of the formula $C_{34}H_{44}O_{21} \cdot 2H_2O$. On hydrolysis it yields glucose, rhamnose, and 5:7:3'-trihydroxy-4'-methoxyflavone (diosmetin). It occurs * in *Hyssopus officinalis*, *Scrophularia nodosa*, *Barosma* spp., *Mentha crispā*, *M. Pulegium*, *Conium maculatum*, *Capsella Bursa-pastoris*, etc.

BUCHU FOLIA

Buchu, B.P. ; *Buchu Leaves* ; F. *Feuilles de Bucco* ;
G. *Buckblätter*, *Buccoblätter*.

Source.—The name buchu is applied to the leaves of several species of *Barosma* grown in South Africa. The leaf official in the British Pharmacopœia is that obtained from *Barosma betulina* (Thunb.) Bartl. and Wendl. and known in English commerce as "short" or "round" buchu.

History.—The use of buchu leaves was learnt from the Hottentots. The first English importation, which appears to have been of the leaves of *B. crenulata*, was consigned to Reece & Co. of London, who introduced it to the medical profession in 1821. At one time the leaves of *B. crenulata* (oval buchu) and *B. serratifolia* (long buchu), which are not now official in the British Pharmacopœia, were preferred to those of *B. betulina*, the authors of the *Pharmacographia* remarking "The leaves of the *B. betulina* are the least esteemed and fetch a lower price than the others yet appear to be quite as rich in essential oil."

Collection and Preparation.—*Barosma betulina* is a small shrubby plant growing wild to the north and north-east of Cape Town. The leaves are principally obtained from wild plants while they are flowering and fruiting. Cultivation of the plants from seed has been tried and shows commercial possibilities, although the percentage of seeds which germinate is small ; cuttings do not root readily. The leaf-bearing shoots should be cut cleanly to avoid injury to the plant, and the leaves carefully dried for about fourteen days. About 200,000 lb. of buchu are now exported annually from South Africa.

Macroscopical Characters.—The leaves of *B. betulina*, *B. crenulata*, and *B. serratifolia* are all small, shortly petiolate,

* Oesterle and Wander, *Helv. Chim. Acta.*, 1925, 8, 519; abstracted in *J.C.S.*, 1925, i, 1438.

green to greenish-yellow in colour, and supplied with numerous oil glands which are readily visible on holding them to the light.

Round or short buchu consists of the leaves and a small percentage of the stems, fruits, and flowers of *Barosma betulina* (Fig. 140, A). The leaves are from 12 to 20 mm. long and from 4 to 15 mm. broad. They are rhomboid-obovate in shape with a blunt and recurved apex. The margin is dentate in the upper two-thirds of the leaf and serrate towards the base. A large oil gland is situated at the base of each marginal indentation and at the apex, whilst numerous smaller ones are scattered throughout the lamina. The leaves when dry are brittle and coriaceous, but on moistening become cartilaginous or mucilaginous. Odour and taste, strong and characteristic. Reddish-brown fragments of stems, up to about 5 cm. in length, brown fruits with five carpels, and flowers with five whitish petals are usually present; but an excessive amount of these must be regarded as an adulteration.

Microscopical Characters.—Microscopic examination of surface preparations shows polygonal epidermal cells with straight walls; stomata on the lower surface only, each surrounded by four to six cells; a few one-celled hairs up to 145μ long, particularly on the midrib. In section the cells of the upper epidermis show a thick cuticle, sphæro-crystalline masses or feather-like crystal aggregates of diosmin, and a thick deposit of mucilage on the inner tangential walls. A single layer of palisade cells is followed by spongy parenchyma, the cells of which contain rosette crystals of calcium oxalate 15 to 30μ in diameter. The oil cavities are circular and lie in the spongy mesophyll. The midrib has a fan-shaped xylem and a crescent of non-lignified* pericyclic fibres between the bast and the sub-epidermal collenchyma.

Varieties.—Oval Buchu is obtained from *Barosma crenulata* Hooker. The leaves, which are accompanied by a certain amount of stem, are 15 to 30 mm. long, and 7 to 10 mm. broad. The shape is more or less oval; the apex is blunt but not recurved and possesses a terminal oil gland; marginal serration very minute.

Long Buchu is obtained from *Barosma serratifolia* Willd. The leaves are 12 to 40 mm. long and 4 to 10 mm. broad; linear lanceolate in shape; the apex is truncate and possesses a terminal oil gland; the margin is serrate.

* Wallis and Dewar, *Y. B. Pharm.*, 1933, 348.

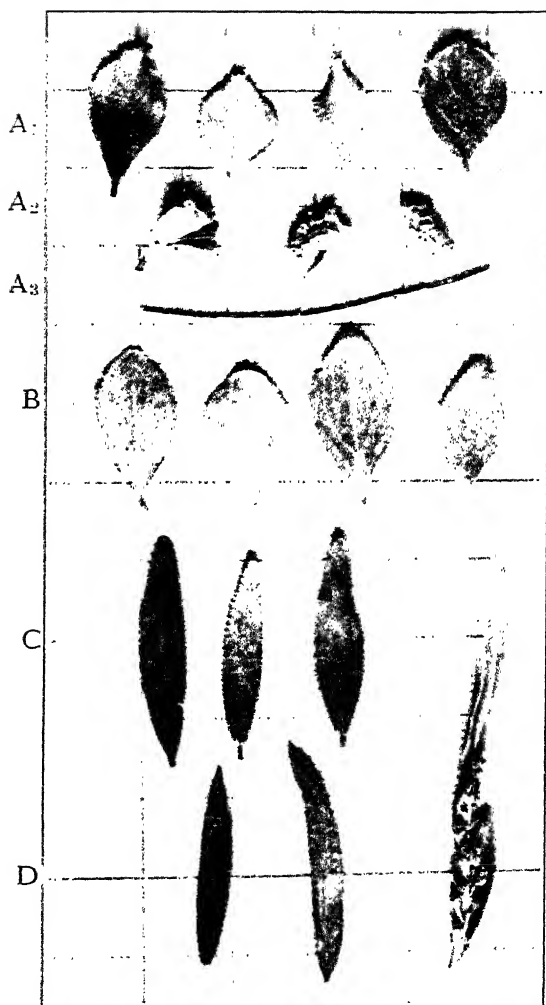


FIG. 110.—A₁, A₂, and A₃ the leaves, fruits and stalk of *Barosma betulina* ;
 B, leaves of *B. crenulata* ; C, leaves of *B. serratifolia* ; D, leaves and
 ; of *Empleurum serrulatum* (Newman).

Substitutes and Adulterants.—Many buchu substitutes have been recorded.* These are usually of Rutaceous origin and belong to genera such as *Barosma*, *Agathosma*, *Diosma*, and *Empleurum*, which are indigenous to South Africa. The following may be mentioned :—

- (a) Resembling *B. betulina* : The leaves of *Barosma venusta* Ecklon and Zeyher resemble the official leaves in general characters but are distinguished by their much smaller size and by the fact that an alcoholic extract gives a strong blue fluorescence in ultra-violet light. Those of *Barosma pulchella* differ in that they are ovate instead of obovate and have a characteristic citronella-like odour.
- (b) Resembling *B. crenulata* : *Barosma Echloniana* Bartl., has sometimes been regarded as a variety of *B. crenulata*. The leaves are, however, somewhat broader and shorter and lack an apical oil gland.
- (c) Resembling *B. serratifolia* : *Empleurum serrulatum* Aiton. Apex acutely pointed and without a terminal oil gland. Bitterish taste and characteristic odour.

Constituents.—Buchu leaves contain volatile oil, diosmin (see p. 421), mucilage, resin, and calcium oxalate. The leaves of *B. betulina* contain 1.3 to 2.5 per cent. of volatile oil; those of *B. serratifolia* 0.8 to 1.0 per cent. The chief constituents of buchu oil are diosphenol, the terpenes *d*-limonene and dipentene, and the ketone, *l*-menthone.

Diosphenol or buchu-camphor, $C_{10}H_{16}O_2$, is a crystalline optically inactive solid, melting at 83° and boiling at 232° . Chemically it is a phenolic ketone. It may be isolated by shaking the oil with sodium hydroxide solution, treating the alkaline liquid with an acid, and recrystallising the crude diosphenol from a mixture of alcohol and ether. The *betulina* oil, estimated by caustic soda absorption, has a diosphenol content of 17 to 30 per cent. and deposits crystals of this substance on standing. Other buchu oils contain diosphenol but not in sufficient quantities to give a deposit of it on standing.

Uses.—Buchu is used as a diuretic in diseases of the urinary organs. Its action is ascribed to the volatile oil.

* For description of many of these, see Holmes, *P.J.*, 1910, 85, 464. Also, Wallis and Dewar, *Y. B. Pharm.*, 1933, 347.

JABORANDI FOLIA

Jaborandi ; *Jaborandi Leaves* ; F. *Feuilles de Jaborandi* ;
G. *Jaborandiblätter*

Source.—The name *jaborandi* is now applied to the leaflets of various species of *Pilocarpus*, a genus of trees and shrubs well represented in South America and found to a less extent in the West Indies and Central America. The principal *jaborandi* now imported, *Maranham jaborandi*, is that derived from the Brazilian plant *Pilocarpus microphyllus* Stapf.

History.—The name *jaborandi* is applied in South America to various plants of the families Piperaceæ and Rutaceæ the leaves of which have an aromatic or pungent taste and increase the flow of saliva when chewed.

Jaborandi was introduced into medicine in 1874 by Dr. Coutinho of Pernambuco. The leaves imported into England as *Pernambuco jaborandi* were for some time regarded as those of *Pilocarpus pennatifolius* Lemaire, but after a study of the drug extending over many years Holmes came to the conclusion that they belonged to a hitherto undescribed species to which he gave the name *Pilocarpus Jaborandi* in 1893. By 1895 the then official Pernambuco leaf was becoming scarce and a number of other kinds were imported, namely, Paraguay (from *P. pennatifolius* Lemaire), Maranham (from *P. microphyllus* Stapf, first imported 1893), Ceara (*P. trachylophus* Holmes, first imported 1894), and Aracati (from *P. spicatus* A. St. Hil.). *Jaborandi* was official in the B.P. 1898, and in the U.S.P. IX, but has now been replaced by pilocarpine salts, the action of which very closely resembles that of the whole drug.

Characters.—1. *Maranham Jaborandi*.—The plant, *P. microphyllus*, which produces the Maranham drug, bears imparipinnate compound leaves with about seven leaflets. The leaflets are attached to a somewhat winged rachis which is almost glabrous (cf. *Swartzia* sp. below). The drug consists of separated leaflets, a certain amount of rachis, and an occasional fruit. The leaflets are 2 to 5 cm. long, 1 to 3 cm. broad, and emarginate at the apex. The terminal leaflets are oval, symmetrical, and have a petiolule 5 to 15 mm. long, with a winged margin which passes imperceptibly into the lamina. The remaining leaflets are obovate, asymmetrical and sessile. Leaflets of the left and right sides of the leaf may be distinguished from one another by the fact that the broader

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side of each leaflet lies away from the rachis. The veins are pinnate and anastomose near the margin. The drug is greyish-green to greenish-brown in colour and brittle in texture. Numerous small oil cells may be seen by transmitted light. Odour, when crushed, slightly aromatic; taste, bitterish and aromatic, the secretion of the salivary glands being much increased.

2. **Pernambuco Jaborandi** consists of the leaflets of *Pilocarpus Jaborandi* Holmes, which are obtained from a com-

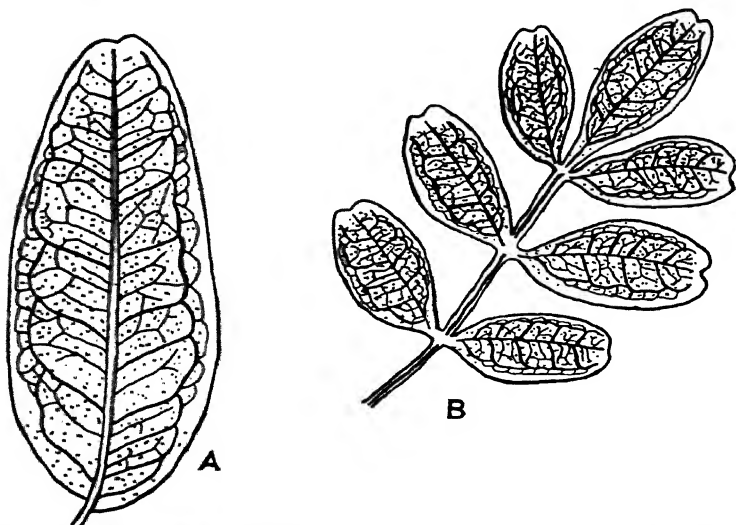


FIG. 141.—A, leaflet of *Pilocarpus Jaborandi*; B, leaf of *Pilocarpus microphyllus*, about two-thirds natural size. (After Tschirch.)

pound imparipinnate leaf with one to nine leaflets. Leaflets 4 to 12 cm. long and 2 to 4 cm. broad; petiolules short; apex emarginate; base usually asymmetric; margin entire and slightly revolute. Upper surface glabrous and greyish to brownish-green; lower surface yellowish- or greenish-brown and slightly pubescent. Midvein not prominent on the upper surface but very prominent on the lower surface (in the midveins of the Maranhão leaflets the reverse is the case). A transverse section of the midveins is often useful for distinguishing between the various species of *Pilocarpus*, e.g.

the Pernambuco variety shows a complete ring of pericyclic sclerenchyma, the Maranhã a broken ring.

3. *Paraguay Jaborandi* derived from *P. pennatifolius* Lemaire. Greyish-green; papery in texture; usually equal at base; veins not prominent on the upper surface and the anastomoses not marked. Pericyclic sclerenchyma more broken than in Maranhã or Pernambuco. The above three varieties have a single palisade layer, a point which distinguishes them from the Guadeloupe and Aracati varieties.

4. *Ceara Jaborandi* is derived from *P. trachylophus* Holmes. It is exported from the Brazilian provinces of Ceara and Maranhão; leaflets smaller than those of *P. Jaborandi*; oblong or elliptical; coriaceous; both surfaces bearing short curved hairs, which are particularly abundant on the lower surface.

5. *Aracati Jaborandi*: *P. spicatus* Ast. Hil., a plant with simple lanceolate leaves 3 to 11 cm. long; short twisted petiole; upper surface shining.

6. *Guadeloupe Jaborandi*: *P. racemosus* from the lesser Antilles; up to 20 cm. long; ovate. The Aracati and Guadeloupe both have a double layer of palisade parenchyma.

7. *Venezuela Jaborandi*: *P. heterophyllus*, a leaf chemically examined in 1923 but containing very little pilocarpine. The author is not aware of it having been imported to any extent.

Adulteration.—Although all the jaborandis mentioned above contain alkaloids, these differ in nature and in the percentage present. Some contain little or no pilocarpine and their presence in Maranhã leaves would be regarded with disfavour by the pilocarpine manufacturer.

Maranhã jaborandi appears to have been more frequently adulterated than the other varieties of Jaborandi, particularly by the leaves of *Swartzia decipiens* Holmes. These leaves are rather smaller than those of *P. microphyllus* and have a short, hairy petiole. The rachis, if present, is cylindrical and pubescent.

In 1875 leaves and roots of a species of *Piper* were imported as jaborandi, but it was not difficult to show that they differed in appearance and constituents from the leaflets of *Pilocarpus* species. Stems were almost invariably present which showed the swollen nodes characteristic of the Piperaceæ.

Constituents.—Maranhã leaves contain about 0.7 to 0.8 per cent. of the alkaloids, pilocarpine, isopilocarpine and pilosine, and about 0.5 per cent. of volatile oil.

Pilocarpine, $C_{11}H_{16}O_2N_2$, was isolated by Hardy in 1871.

It is now known to be the lactone of pilocarpic acid, an acid which contains a glyoxaline nucleus. It can, with difficulty, be obtained crystalline but readily forms crystalline salts. By the action of heat or alkalis pilocarpine is converted into its isomer *is*-pilocarpine. *Isopilocarpine* occurs in small quantity in the leaf but more is formed during the extraction process. *Pilosine*, which is only found in small quantities, was isolated by Pyman in 1912. Alkaloids other than the three mentioned above have been isolated from other species, namely, *pilocarpidine* (from Pernambuco) and *ψ*-pilocarpine and *ψ*-jaborine (from Aracati). The nature of the alkaloids of Ceara is not known. The amount of crystalline pilocarpine nitrate which can be prepared from the different varieties has been given as 0.67 per cent. from Pernambuco ; 0.45 per cent. from Maranhão ; 0.12 per cent. from Guadeloupe ; and 0.04 per cent. from Venezuelan.

Uses.—*Mydriaphoretic*, used in kidney disease ; *sialogogue* ; *emetic* in large doses. A constituent of many hair restoring preparations. Salts of pilocarpine are usually preferred to galenicals made from the whole drug. Pilocarpine causes contraction of the pupil of the eye, its action being antagonistic to that of atropine.

AURANTII AMARI CORTEX

Cortex Recens, B.P. ; Aurantii Cortex Siccatus, B.P. ; Bitter Orange Peel ; F. Écorce ou Zestes d'Oranges Amères ; G. Pomeranzenschale

-Bitter orange peel is obtained from the fruit known as the bitter, Seville, or Bigarade orange. The tree producing these fruits does not differ very markedly in botanical characteristics from the sweet orange tree and they are regarded as subspecies or varieties of *Citrus Aurantium* Linn. These are named respectively *Citrus Aurantium* var. *amara* Linn. (*C. Bigaradia* Durham ; *C. vulgaris* Risso), and *C. Aurantium* var. *dulcis* Linn. (*C. sinensis* Galesio).

The bitter orange is not as widely cultivated as the sweet orange and our supplies are obtained chiefly from Southern Spain (Seville and Malaga), Sicily (Messina and Palermo), and Tripoli via Malta.

History.—The bitter orange tree appears to have been introduced from Northern India into Eastern Africa, Arabia, and Syria, whence it was brought to Europe either by the

Arabs or Crusaders about A.D. 1200. The sweet orange was not known in Europe until the fifteenth century and appears to be of Chinese origin. The peel of the bitter orange is official in the British Pharmacopœia and those of both the bitter and the sweet orange in the U.S. Pharmacopœia.

Collection and Preparation.—Orange peel may be prepared in the Mediterranean countries or in England. In the latter case the fruits are collected before they are quite ripe and the

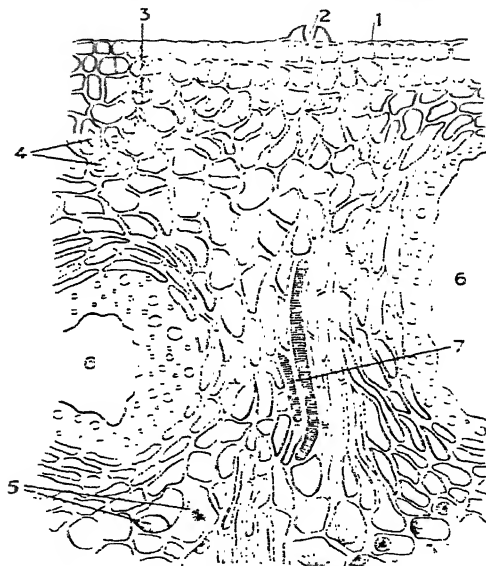


FIG. 142.—*Citrus Aurantium* subsp. *amara*. Transverse section of the outer part of the unripe fruit. 1, epicarp; 2, stoma; 3, crystal of calcium oxalate; 4, hesperidin in masses; 5, hesperidin in crystals; 6, secretion cavity; 7, vascular bundle. (After Tschirch.)

ripening is completed in transit. January, February, and March are the chief months for their importation.

The peel should be removed with as little of the white "zest" as possible. Hand-cut, English dried peel is most esteemed. The peel may be removed in four "quarters," or in a spiral band. It is also met with in thin strips, similar to those found in marmalade, cut by machines. The so-called Maltese is of this type, which is known as "gelatin-cut."

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Fine slicing naturally causes the rupture of a large number of oil glands and some loss in aroma.

Characters.—The colour of the dried peel is somewhat variable, but frequently reddish-brown in the spiral form and greenish-brown in the "quarters." The outer surface is rugged, being somewhat raised over the oil glands, which are clearly seen in sections with the naked eye. The inner surface bears a small amount of white "zest." Fragrant odour; aromatic and very bitter taste.

Microscopic examination shows a small-celled epidermis with characteristic stomata; parenchyma containing prismatic crystals of calcium oxalate 20 to 45 μ long, or sphæro-crystalline masses of hesperidin; small anastomosing vascular bundles; and large oil-containing cavities usually arranged in two, irregular rows.

Constituents.—Bitter orange peel contains about 1 to 2.5 per cent. of volatile oil and the rhamno-glucoside, hesperidin. "Isohesperidin," aurantiamarin, an amorphous glycosidal bitter substance, bitter aurantiamaric acid, a bitter resin, and the tasteless crystalline substance, hesperic acid, are also said to be present.

The volatile oil may be extracted by means other than distillation (cf. oil of lemon) and is known as *Essence de Bigarade*. A similar oil from the sweet orange is called *Essence de Portugal*. These oils contain the terpene, *d*-limonene, and small quantities of citral, citronellal, methyl anthranilate, etc. By removing about 95 per cent. of the terpenes by fractional distillation a "terpeneless oil of orange" may be prepared. Ash 3.5 to 6.5 per cent.

Uses.—Bitter orange peel is used as a flavouring agent and as a bitter tonic.

SUBSTITUTES AND ADULTERANTS

Sweet Orange Peel.—According to the *Pharmacographia* there are but few districts in India where the cultivation of the bitter orange is successful. In parts of the Empire where supplies of fresh bitter orange peel are difficult to obtain the Pharmacopœia allows sweet orange peel to be used instead.

The peel of the sweet orange is thinner than that of the bitter, more yellowish in colour, less rough, and the taste,

though pungent and aromatic, lacks the extreme bitterness of the Seville peel.

Lemon peel, which is described below, is not difficult to distinguish from orange peel. As a confirmatory test a section may be moistened with concentrated hydrochloric acid when lemon peel undergoes but little change, while orange peels (both bitter and sweet) develop a green colour.

LIMONIS CORTEX

Limonis Cortex, B.P. ; Lemon Peel ; F. Écorce ou Zeste de Citron ; G. Citronenschale, Limonenschale

Source.—Lemon peel is obtained from the fruit of *Citrus Limonia* Osbeck (*Citrus medica* var. *Limonum* Linn. ; *C. Limonum* Risso), a small tree, 3 to 5 metres high, cultivated in the countries bordering the Mediterranean. The lemons imported from Sicily (Messina and Palermo), Southern Italy (Reggio), and Southern Spain (Murcia) are most esteemed. Lemons are also grown in Australia, Florida, California, and Jamaica.

History.—The lemon is of Indian origin and appears to have been unknown in Europe until the twelfth century. Numerous varieties and hybrids (particularly with *Citrus medica* Risso) are cultivated. Fresh lemon peel is official in the British Pharmacopœia.

Collection and Preparation.—Lemons are collected in January, August, and November, before their green colour changes to yellow. They are exported in cases containing from 200 to 360 fruits. The smaller fruits, which would not have a ready sale, are used in the preparation of oil of lemon. For pharmaceutical purposes fresh peel should be used whenever possible, although dried peel is officially sanctioned in countries where fresh lemons are not obtainable. The peel is removed with a sharp knife in the form of a spiral band.

Characters.—Dried lemon peel occurs in spiral bands up to 2 cm. in breadth and from 2 to 3 mm. thick. Some pieces bear the apex of the fruit which has a nipple-like appearance. The outer surface is rough and yellow ; the inner surface pulpy and white. Odour strong and characteristic ; taste aromatic and bitter.

The anatomical structure closely resembles that of orange

peel (*q.v.*). The epidermis bears stomata. The large, schizolysigenous oil cavities lie close to the surface and are usually arranged in a single, somewhat uneven row. The yellow outer layers of parenchyma contain prisms of calcium oxalate and yellowish masses of hesperidin. The white, inner region consists of branched cells with large, air-filled, intercellular spaces, and of small vascular bundles.

Constituents.—Lemon peel contains volatile oil (see below), hesperidin, bitter principles, mucilage, and calcium oxalate.

Uses.—Lemon peel is mainly used for flavouring purposes.

OLEUM LIMONIS

Oleum Limonis, B.P. ; *Oil of Lemon* ; F. *Huile Volatile de Citron* ; G. *Citronenöl*

Source.—Oil of Lemon is a volatile oil obtained from the fresh pericarp of the lemon, *Citrus Limonia* Osbeck. It is produced in Sicily (particularly in the Messina district), in Southern Italy (Calabria), and the French and Italian Rivas. Other lemon cultivating countries such as California, Australia, Florida, and Jamaica are likely to become serious competitors in the oil of lemon market in the near future. California exports a considerable quantity of distilled oil of lemon. Oil of lemon and other *Citrus* oils, unlike most of the other essential oils used in medicine, are of much better quality when prepared by expression than when prepared by distillation.

History.—Both expressed and distilled oils of lemon were sold in Paris as early as 1692. Expressed oil of lemon is official in Britain and the U.S.A.

Preparation.—Oil of lemon is, or has been, prepared by the following processes: (1) The spugna or sponge process and a variation of this called the scorzetta process, (2) the *écuelle à piquer* process, (3) expression of raspings process, (4) machine processes, and (5) by distillation.

(1) **The sponge processes** are used in Sicily, Calabria, and the Riviera. The spugna process is described by Barrett* as follows:—

“The principle on which the extraction of the essence is carried on may be illustrated in this way. If you hold a piece of lemon peel up to the light, and turn it inside out, a fine shower of mist will be seen to be forcibly ejected. This is not all oil, but a mixture of oil and water.

* *Y. B. Pharm.*, 1892, 505.

Most people are unpleasantly acquainted with this phenomenon, though many may not have actually seen it, for in peeling a lemon or orange with the fingers a little of the oil is often ejected into the eye, causing a considerable amount of pain. By turning the lemon peel inside out almost the whole of the essence is removed from the peel, for each little globule of oil appears to be surrounded by water, and the liquid which remains adherent to the peel consists principally of water. As it is impossible to turn every piece of peel actually inside out, the following method is adopted: One man takes a lemon in his hand, and with three rapid strokes with a large knife cuts off nearly all the peel in three slices. The central portion which is left consists of most of the pulp with a little of the peel—top and bottom. This is simply pressed for making lemon juice. The slices pass to a second workman who sits on a low chair with an ordinary common quality bath sponge, worth about 6d., in one hand. With the other he presses the slice of peel against the sponge, pressing the edges of the peel only with his fingers, the object being to press the convex piece of lemon peel as nearly flat as possible. The amount of pressure used is very slight, and at first sight it seems incredible that the oil globules can have been broken; but if you try the experiment of turning this exhausted peel inside out, nothing more can be extracted. The sponge is periodically squeezed. One man working in this way can extract about 1½ lb. (English) essence of lemon per day. To ensure the cells being fully charged with moisture, it is usual to allow the lemons to stand in water for a short time; and I myself propose washing the lemons in a stream of running water."

In the Scorzetta process the lemons are cut in half, the pulp removed with a spoon-like instrument (Fig. 143), and the peel squeezed against a sponge (Fig. 144). The pulp from the sponge processes is expressed and the juice used for the manufacture of citric acid, the residual cake being used as a cattle food.

(2) *Écuelle à Piquer* Process.—On the Riviéras an instrument known as an *écuelle à piquer* (literally, a bowl for pricking) may still be used.* This consists of a funnel made of copper and tinned inside. The upper saucer-like part is about 8 to 10 inches in diameter and bears on its inner surface numerous strong metal pins about ¼-inch

* Inquiries have been made on the Continent with the object of obtaining an *écuelle à piquer*, which is described in text-books and illustrated by Tschirch. It appears, however, that the process is almost obsolete in the case of oil of lemon and that the name *écuelle à piquer* is now applied to a portion of an oil-extracting machine. The process is in use for the extraction of oil of limes in the West Indies.

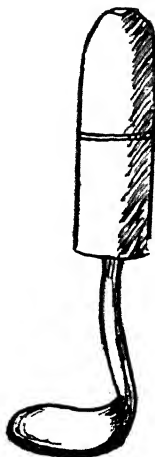


FIG. 143. — Instrument used for removing pulp from lemons.

to $\frac{1}{2}$ -inch long. The stem-like portion is about 5 inches long and 1 inch in diameter and serves both as a handle and as a receiver for the oil. By rapidly rotating the instrument, after placing lemons in the bowl the oil glands are punctured and discharge their contents, which collect in the handle. The liquid is poured off at intervals into a larger vessel, where it is allowed to stand until the oil can be decanted and filtered.

(3) **Expression of Raspings Process.**—This method is now little used but the principle is interesting. The outer region of the peel, which contains the oil glands, is removed by means



FIG. 144.—Manufacture of oil of lemon. Sponge process (Lautier Fils).

of a grater. The raspings are placed in horsehair or duck bags and strongly pressed. The liquid obtained is turbid but on standing the oil separates and can be decanted and filtered.

(4) **Machine Processes.**—Much oil is prepared by machines based on the above principles and is only slightly inferior to the hand-pressed oil. One of these is illustrated in Fig. 145.

(5) **Distillation.**—Oil obtained by distillation is not comparable with that which is expressed, but large quantities are so prepared, particularly in California. Oil may be distilled from the peel-residues of the expression processes. For details

of machine and distillation processes the student is referred to Parry's *Chemistry of Essential Oils and Perfumes*.

Varieties.—Sicilian "hand-pressed" oil fetches the highest price, Sicilian "machine-made" being slightly cheaper. "Distilled Californian" is usually about half the price of the Sicilian "hand-pressed."



FIG. 145.—Manufacture of oil of lemon. Machine process (Lautier Fils).

Constituents.—Lemon oil contains terpenes (about 94 per cent., mainly *d*-limonene), sesquiterpenes, aldehydes (citral, about 4 to 5 per cent., and citronellal), and esters (about 1 per cent. geranyl acetate). Limonene is a liquid, b.p. 175°. Citral or geranial, a liquid, b.p. 230°, is the aldehyde corresponding to the alcohol geraniol. Lemon oil shows a marked tendency to resinify and should be protected from the action of air and light as much as possible.

Terpeneless oil of lemon is prepared by distilling a good lemon oil under reduced pressure until the distillate contains most of the terpenes and about 2 per cent. of the citral. The residue is the so-called terpeneless oil, which has a citral content of 40 to 50 per cent.

Adulteration.—Oil of lemon was at one time frequently adulterated with oil of turpentine, but analysts now have to contend with more scientific methods of adulteration. These include the addition of terpenes obtained in the preparation of "terpeneless oil of lemon," and the addition of the cheaper distilled oil of lemon. The value of the oil is judged to some extent on the citral content, but a normal citral content alone is not a sure indication of purity since citral may be added from a cheaper source such as oil of lemon grass, which contains 75 to 85 per cent. of this aldehyde. It will be gathered that a careful examination of the oil by both physical and chemical methods is necessary.

Uses.—Oil of lemon is used for flavouring and in perfumery.

Succus Limonis.—Lemon juice, although no longer official, is an important source of citric acid and vitamin C. In Sicily and Calabria the pulp, separated during the extraction of oil of lemon, is pressed, the fruits yielding about 30 per cent. of juice. This is concentrated from its natural specific gravity of 1.03 to 1.04 to a specific gravity of about 1.23, forming a very dark brown liquid. Some is exported for citric acid manufacture, but much is treated in Italy for the extraction of calcium citrate or citric acid. Considerable quantities of citric acid and calcium citrate are obtained from lime and lemon juices produced in the West Indies (Antilles), Spain, and California. Lemon juice, *Succus Limonis* B.P.C., is used for its vitamin C content. Orange juice, however, is richer in this vitamin and is more suited to infant feeding. Decitrated orange and lemon juices are used for making vitamin C concentrates.

BELÆ FRUCTUS

Indian Bael Fruit, Bengal Quince ; F. Marmelos de Benguala ; G. Indische Quitten, Marmelosfrüchte

Source.—Bael fruit is obtained from the *Egle Marmelos* Correa, a tree 10 to 13 metres high, grown in India. For medical purposes the fresh half-ripe fruit is preferred.

History.—The tree has long been held sacred by the Hindus and is referred to in Sanskrit writings of about 1000 B.C. Its use for dysentery was known to the Portuguese at Goa in the sixteenth century, but the drug attracted little attention in Europe until 1850. It was official in the 1914 Pharmacopœia, but is not now included in either the British or U.S. Pharmacopœias.

Characters.—The half-ripe fruits are about 6 to 8 cm. in diameter and in general structure resemble an orange although the shape is rather more variable. The rind, which is about 3 mm. thick and very hard, encloses ten to fifteen cells each containing mucilaginous pulp and a number of immature hairy seeds. The fresh fruit is aromatic and the pulp has an agreeable somewhat acid taste.

The dried fruit is imported whole, in quarters, or transverse slices. The dried pulp is hard and adheres firmly to the rind. Sections of the rind show an outer zone containing oil cells and an inner zone of sclerenchyma.

Constituents.—The constituents of bael, apart from the mucilage, are virtually unknown. Although the drug is widely used in India for dysentery and diarrhœa, no tannin-like bodies can be detected in the unripe fruits, but traces are found in the ripe fruit.

Family

A family of 30 genera and 150 species of shrubs or trees, many of which contain bitter principles. It differs from the Rutaceæ in that there are no oil glands. Cork arises superficially. *Ailanthus glandulosa*, Tree of Heaven, is widely cultivated and its leaves have been used to adulterate belladonna and mint.

QUASSIÆ LIGNUM

Quassia B.P. : *Quassia* Wood, Jamaica *Quassia* ; F. *Bois de Quassie de la Jamaïque* ; G. *Jamaica Quassiaholz*

Source.—Official quassia is the stem wood of *Picræna excelsa*) Lindl. (*Picrasma excelsa* (Sw.) Planchon *), which is known in commerce as Jamaica quassia. This wood is also used in America, but most Continental pharmacopœias prefer to include the wood of *Quassia amara* Linn., which is known as Surinam quassia. *Picræna excelsa* is a tree 15 to 20 metres high which grows in the West Indies (Jamaica, Guadeloupe, Martinique, Barbadoes, and St. Vincent). *Quassia amara* is a shrub 1 to 2 metres high which grows in the Guianas, northern Brazil, and Venezuela.

History.—Surinam quassia was introduced into medicine by a negro of the name of Quassi about the middle of the eighteenth century. This quassia, which consisted of the wood, bark, and roots, was introduced into the London Pharmacopœia of 1778 but was superseded by the wood of *Picræna excelsa* in the edition of 1809.

Macroscopical Characters.—Quassia occurs in logs, chips, or raspings. The logs are of variable length and up to 30 cm. in diameter (those of Surinam quassia never exceed 10 cm. in diameter). The logs are covered with a dark grey cork which readily separates from the phloem. The wood is at first whitish but becomes yellow on exposure. It frequently shows blackish markings owing to the presence of a fungus. The logs split readily and the commercial chips, which are cut across the grain, break very readily into smaller fragments. The drug has no odour but an intensely bitter taste.

The commercial chips usually contain bark in addition to the wood. Examined in ultra-violet light, the cork shows blue and yellow patches on a velvety brown background; the phloem fluoresces an intense greyish-white; the regions attacked by fungus become violet, and the false annual rings (see below) become very distinct and fluoresce a much brighter yellow than the remainder of the wood.

Microscopical Characters.—A transverse section of quassia (Fig. 146) shows medullary rays, which are mostly 2 to 5 cells wide. Interrupted tangential bands of wood parenchyma,

* Several synonyms have been used and *Picrasma excelsa* is the one given in Thoms' *Handbuch der Pharmazie* and Rendle's *Classification of Flowering Plants*.

which are known as false annual rings, alternate with bands of wood fibres and vessels. In many of the cells of the wood parenchyma are prisms of calcium oxalate, each about $6-30\mu$ long and enclosed in a delicate membrane. The vessels are large and occur singly or in groups of two to eleven which extend from one medullary ray to the next.

Radial and tangential longitudinal sections show that the medullary rays are mostly from ten to fifteen cells high; that the wood fibres are long and finely pointed; and that the vessels have finely pitted walls. Starch grains are few; mostly

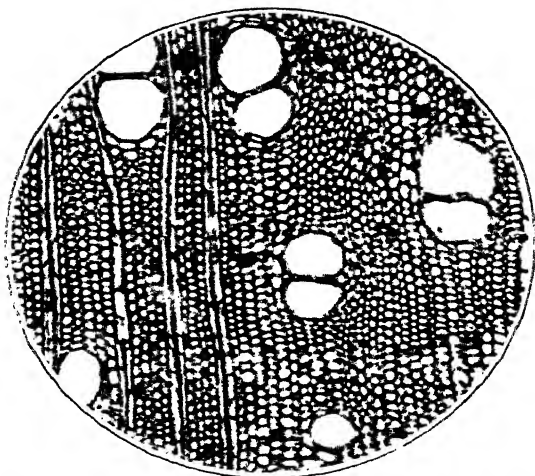


FIG. 146.—Transverse section of Jamaica quassia wood (Sutcliffe).

simple, spherical and about $5-15\mu$; occasionally 2-compound. For powder, see p. 108.

Constituents.—The constituents of quassia appear to require further investigation. According to Massute (1890) the drug contains three crystalline bitter principles, namely, α -picrosmin, $C_{35}H_{46}O_{10}$ (m.p. 204°), β -picrosmin, $C_{36}H_{48}O_{10}$ (m.p. 209° to 212°), and a small amount of a third of the formula $C_{29}H_{34}O_{10}$ (m.p. 212° to 216°). Quassia also contains a substance which gives a strong blue fluorescence to acidified alcohol. It yields about 6.3 to 9.6 per cent. of aqueous extract. Tannin is absent.

Allied Drugs.—Surinam quassia occurs in smaller billets than

those of Jamaica quassia. The medullary rays are only one or two cells wide but up to thirty cells deep. Calcium oxalate is absent. The drug contains a mixture of bitter principles termed "quassin" and a fluorescent principle. The fluorescence resembles that of the Jamaica drug.

Uses.—Quassia is used as a bitter tonic and as an insecticide.

Family **BURSERACEÆ**

The Burseraceæ includes 13 genera and about 400 species. It is well represented in North-East Africa, Arabia, and tropical America. The leaves, like those of the Rutaceæ, are gland-dotted, and a disc is present between the stamens and the ovary. Cork arises superficially. Oleo-resin canals are found in the bast and, in some species of *Boswellia* and *Canarium*, in the pith. Of medicinal interest are *Commiphora molmol* (myrrh), *C. erythæa* var. *glabrescens* (perfumed bdellium) *Boswellia Carterii* (olibanum), *B. Frereana* (East African elemi), *Canarium luzonicum* (Manila elemi), *Protium heptaphyllum* (Brazilian elemi), *Amyris Plumerii* (Yucatan elemi) and *A. balsamifera* (West Indian Sandal wood).

Olibanum: Frankincense.—Olibanum is an oleo-gum-resin obtained by incision from the bark of *Boswellia Carterii* and other species of *Boswellia*, small trees indigenous to North-Eastern Africa and Arabia. The drug occurs in more or less ovoid tears, 5 to 25 mm. long, which are sometimes stuck together. The surface is dusty and of a yellowish, bluish or greenish tint. Fracture, brittle; inner surface, waxy and semi-translucent. Odour, characteristic, especially when burned; taste, slightly bitter. The drug contains 3 to 8 per cent. of volatile oil, about 60 to 70 per cent. of resin and 27 to 35 per cent. of gum. It is used in incense and fumigating preparations.

MYRRHA

Myrrha, B.P.; *Myrrh*, Arabian or Somali *Myrrh*;
F. *Myrrhe*; G. *Myrrha*

Source.—Myrrh is an oleo-gum-resin, obtained from *Commiphora molmol* Engler (*Commiphora Myrrha* Holmes), and possibly other species of *Commiphora*. *Commiphora molmol*, the Dhidin tree, is a tree about 3 metres high of "crippled" appearance growing in North-East Africa and Arabia. Two other species, *Commiphora abyssinica* Engl. and *C. Schimperi* Engl., both of which may attain a height of 10 metres, grow

in Arabia and Abyssinia. The drug is chiefly collected in Somaliland and sent to Aden, whence it reaches London either direct or *via* Bombay.

History.—Products of the myrrh type were well known to the ancients under the names of *Bola*, *Bal*, or *Bol*. The drug is still known to the Indian traders as “Heerabol,” while the Somalis call it “Mulum” or “Ogo.” The name myrrh is probably derived from the Arabic and Hebrew word *Mur*,



FIG. 147.—Bags of Myrrh sorts in the Cutler Street Drug Warehouse
(*Chemist and Druggist*).

which means bitter. Many references occur in the Old Testament, but the product was apparently that derived from *C. erythæa* var. *glabrescens*, which is known to the Somalis as “Habbak hadi,” and in commerce as perfumed bdellium or bissabol.

Guban myrrh, which is produced from trees of the Somali coast area known as the Guban, is rather oily and is regarded as inferior to the more powdery “ogo” produced further inland. The latter variety corresponds to “good Aden sorts.”

Collection.—Almost all members of the Burseraceæ possess in their phloem oleo-resin canals, which are formed schizogenously and may afterwards unite with one another to form schizolysigenous cavities. This occurs in the species of *Commiphora*. Much of the secretion is obtained by spontaneous exudation from the cracks and fissures which commonly form in the bark, and some is obtained from incisions made by the Somalis. The yellowish-white, viscous fluid soon hardens in the great heat to reddish-brown masses, which are collected by the Somalis in goatskins. As the natives collect bdelliums and gums at the same time, these frequently find their way into the drug and have subsequently to be picked out. The drug is usually sent from Aden in sacks (see Fig. 147).

Characters.—Myrrh occurs in somewhat irregular tears or masses weighing up to about 250 G. The surface is reddish-brown or reddish-yellow in colour and powdery. The drug fractures and powders readily, the freshly exposed surface being of a rich brown colour and oily. Whitish marks are sometimes seen, and thin splinters are translucent. Myrrh has an aromatic odour and an aromatic, bitter, and acrid taste.

Myrrh forms a yellowish emulsion when triturated with water. When extracted with alcohol (90 per cent.), as in the preparation of Tincture of Myrrh, a whitish mass of gum and impurities remains. The alcohol-insoluble matter should not exceed 70 per cent. Lump myrrh usually yields not more than 5 per cent. of ash, but the commercial powdered drug frequently yields more.

Myrrh may be distinguished from perfumed bdellium and similar products by allowing an ethereal extract of the drug to evaporate to dryness and passing the vapour of bromine over the resinous film produced. A violet colour is given by genuine myrrh but not by bdellium.

Constituents.—Myrrh contains 3 to 10 per cent. of volatile oil, 25 to 40 per cent. of resin, 50 to 60 per cent. of gum and a variable amount of moisture and impurities.

The volatile oil is lævorotatory and contains terpenes, sesquiterpenes, esters, cuminic aldehyde and eugenol. It readily resinifies and then gives a violet colour with bromine.

By means of ether the resin may be divided into a larger, ether-soluble portion and a smaller, ether-insoluble portion. According to Friedrichs (1907), it consists of ether-soluble resin acids (α -, β -, and γ -commiphoric acids), ether-insoluble resin acids, resenes, and complex phenolic compounds.

The gum is of the acacia type and yields arabinose as a product of hydrolysis. It is associated with an oxydase.

Allied Drugs.—Four different varieties of "bdellium" are recognised by Holmes. Of these, *perfumed* or *scented bdellium* or *bissabol* is probably derived from *C. erythæa* var. *glabrescens*. It resembles soft myrrh in appearance but is easily distinguished from it by the more aromatic odour and by the fact that it does not give a violet colour with the bromine test. *Hotai bdellium* or *gum hotai* is opaque and odourless; it contains a saponin and is used for washing the hair.

Uses.—Myrrh is used in incense and perfumes. Like many other resins it has local stimulant and antiseptic properties. It is chiefly employed in medicine in the form of a mouth wash.

Order POLYGALALES

An order consisting of the family Polygalaceæ, the systematic position of which is somewhat doubtful.

Family POLYGALACEÆ

A family of 10 genera and about 680 species, of which 450 belong to the genus *Polygala*. The family is represented in Britain by the milkwort, *Polygala vulgaris*. The genus *Krameria* is sometimes included in this family (see Leguminosæ).

SENEGÆ RADIX

Senega, B.P.; *Senega Root*; F. *Racine de Sénéga*; G. *Senegawurzel*

Source.—Senega consists of the dried rootstock and root of *Polygala Senega* Linn., a perennial herb about 20 to 30 cm. in height. The plants have gradually disappeared from Eastern Canada and the Eastern U.S.A., where they were formerly abundant, and collection now takes place further westward. The annual consumption of the drug is about 500,000 lb., some 90 per cent. of which comes from the western provinces of Canada.

History.—Senega was used by the North American Indians as a snake-bite remedy. It was employed by Tennent in 1734 for pleurisy and pneumonia, and its value was made known in London in 1738.

Macroscopical Characters.—Senega occurs in pieces 5 to 20 cm. long and 2 to 12 mm. in diameter. The lower part is yellowish in colour but the crown is somewhat darker. The latter is knotty and bears numerous, often purplish, buds and the remains of aerial stems. The stems should not form more than 5 per cent. of the drug. The tapering and often curved root frequently divides into two or more branches. Some, but by no means all, of the pieces bear a keel or ridge in the form of a rapidly descending spiral (Fig. 148). The drug frequently has a marked odour of methyl salicylate. Taste, at first sweet, afterwards acrid. The saponins present cause

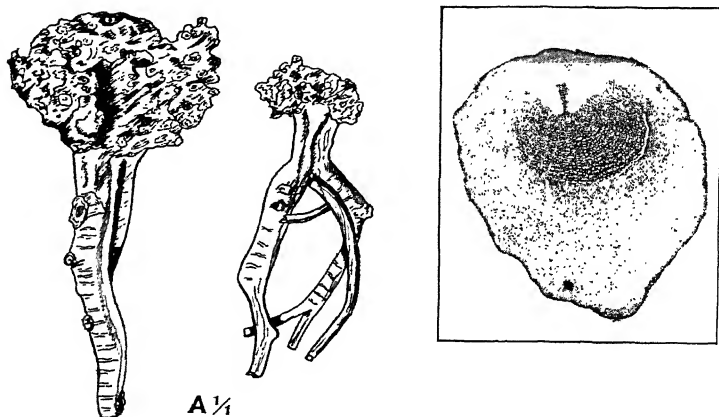


FIG. 148.—*Polygala Senega*. A, roots; B, transverse section of root, showing keel and wedges of parenchyma.

the drug to have sternutatory properties and to froth when shaken with water.

Microscopical Characters.—Transverse sections of different senega roots have widely different appearances. Some have a normal bark, which occupies nearly half the radius, and a uniform central wood with narrow medullary rays. In others, however, an abnormal local development of phloem gives rise to the keel, while one or more exceptionally wide, V-shaped, medullary rays give a very characteristic appearance to the wood. This is well seen in sections stained with phloroglucinol and hydrochloric acid. The parenchyma contains small

globules of oil, but starch and calcium oxalate are absent. The wood is composed of small vessels ; bast fibres and sclerenchymatous cells are absent.

Constituents.—Senega contains an acid saponin, polygalic acid, and a neutral saponin, senegin. These are said to be present only in the bark. The drug also contains 0.25 to 0.30 per cent. of methyl salicylate and about 5 per cent. of fixed oil. The methyl salicylate is probably produced from a glycoside, possibly the one of which Kain (1898) obtained indications. Senega yields about 4 per cent. of ash.

Varieties.—In addition to the Western Senega described above, the following are used, particularly in America.

Northern Senega is derived from *P. Senega* var. *latifolia*, and is collected in the Western U.S.A. The root is somewhat larger, darker in colour, and less markedly keeled than the East Canadian drug.

Southern or *White Senega* is collected in the Southern U.S.A. from *P. alba* Nutt. and *P. Boykinii* Nutt. The roots are smaller than those of *Polygala Senega* and have a normal wood. They appear to be less active than the official drug but are employed in the U.S.A.

Uses.—Senega is used as a stimulant expectorant in chronic bronchitis. It is often prescribed with other expectorants such as ipecacuanha and ammonium carbonate.

Order CELASTRALES

An order including the Aquifoliaceæ and Celastraceæ.

Family **AQUIFOLIACEÆ**

A family of three genera and 287 species, most of which belong to the genus *Ilex* (holly).

MATÉ FOLIA

Maté ; Yerba Maté ; Paraguay Tea

Source.—Maté consists of the dried and cured leaves of *Ilex paraguensis* and other species of *Ilex*, small trees or shrubs indigenous to the region where the Argentine, Paraguay and Brazil meet. The drug is obtained partly from wild plants, e.g. in Brazil, and partly from cultivated ones, which are extensively grown in the Argentine.

Collection and Preparation.—The branches are cut when the

fruits are ripe and "toasted" for a moment over a fire until they show blisters. The leaves are then separated and spread on a platform over a small wood fire for about 24 to 36 hours. They are then reduced to a coarse powder and put into sacks (formerly into hide serons), in which the leaf should be allowed to mature for at least a year. Rapid drying in ovens, although sometimes practised, gives an inferior product.

Characters.—The whole leaves, although seldom seen in commerce, are shortly petiolate, ovate or oblong-lanceolate, 5 to 15 cm. long, and dark green to yellowish-green in colour. They have a crenate-serrate margin and coriaceous texture. The commercial drug consists of fragments of leaf with a variable amount of "stalk." It has a characteristic odour and a somewhat bitterish taste.

Constituents and Uses.—Maté contains about 0.2 to 2 per cent. of caffeine and about 7 per cent. of astringent substances, such as chlorogenic acid (caffeotannic acid), and a little volatile oil. It is said to be very rich in vitamins. Maté tea is very widely used in South America and its consumption in Europe and America is increasing.

Family CELASTRACEÆ

A family containing 45 genera and 450 species. Represented in Britain by the Spindle-tree, *Euonymus europæa*.

EUONYMI CORTEX

Euonymus or *Wahoo Bark*; F. *Écorce Ed'vonymus*;
G. *Spindlebaumrinde*

The euonymus bark formerly official was the root bark of *Euonymus atropurpureus*, a shrub grown in the Eastern U.S.A. The stem bark is also used in medicine.

The root bark occurs in quilled or curved pieces up to 7 cm. long, 12 mm. wide, and 4 mm. thick. The outer surface is covered with a light grey cork, which often bears earth. The inner surface is a pale tawny-white and sometimes has fragments of yellow wood adhering to it. If the bark is broken and the pieces are carefully drawn apart strands of a rubber-like substance are seen. These are produced by latex cells in the phloem.

The stem bark contains chlorophyll and bast fibres, both of which are absent from the root bark.

Euonymus contains crystalline alcohols (dulcitol, euonymol, etc.) and resin. The drug has been employed for its cathartic action but is now little used.

Order RHAMNALES

An order resembling the Celastrales. It contains the families Rhamnaceæ and Vitaceæ.

Family RHAMNACEÆ

A family containing 45 genera and 500 species. It is represented in Britain by *Rhamnus Frangula* (Alder Buckthorn) and *Rhamnus cathartica* (Buckthorn).

RHAMNI PURSHIANÆ CORTEX

Cascara Sagrada, B.P. ; *Cascara Bark*, *Sacred Bark*, *Chittam Bark* ; F. *Écorce Sacrée* ; G. *Sagradarinde*

Source.—Official cascara sagrada is the dried bark of *Rhamnus Purshiana* DC., which is stored for at least one year before being used. The bark is collected from trees, which are 6 to 18 metres high, grown on the Pacific coast of North America (British Columbia, Washington, Oregon, and California). The drug was formerly collected from wild trees growing in the U.S.A., but as these became somewhat depleted an increasing quantity was obtained from British Columbia. Systematic cultivation is now carried on both in America and in Kenya.

History.—Few of the present generation of pharmacists realise that cascara is a drug of comparatively recent introduction into modern medicine. According to tradition a cascara, probably *R. californica*, was known to the early Mexican and Spanish priests of California. *Rhamnus Purshiana*, however, was not described until 1805 and its bark was not introduced into medicine until 1877.

The common, European buckthorn was well known to the Anglo-Saxons ; its berries were official in the London Pharmacopœia of 1650.

Collection and Storage.—The bark is collected from mid-April to the end of August, when it separates readily from the

wood. Longitudinal incisions about 2 to 4 inches apart are first made in the trunk and the bark removed. The tree is then usually felled and the branch bark separated. The pieces are dried in the shade with the cork uppermost. When dry, the bark is placed in sacks (Fig. 149), being usually broken somewhat to reduce bulk. During preparation and storage the bark must be protected from rain and damp, or partial extraction of the constituents may occur or the bark become mouldy. The bark must be kept for at least one year before use, and it increases in medicinal value and price until it is



FIG. 149.—Cascara in store (Boots Pure Drug Co., Ltd.).

about four years old. The age is usually taken from the date of its arrival in London, which is marked on the bales. Many firms prefer to use bark which has been stored for considerably more than one year.

Macroscopical Characters.—The bark occurs in quills, channelled or nearly flat pieces. All of these forms may attain 20 cm. in length and are from 1 to 4 mm. thick, the thinner bark being most esteemed.* The flat strips from the trunk are usually much wider (up to 10 cm.) than the quills or channelled pieces (about 5 to 20 mm.) obtained from the branches.

* The bark now being imported from Kenya is from young trees and is under 1 mm. thick. See *Bull. Imp. Inst.*, 1937, 35, 424.

Cascara bears a somewhat patchy, silvery-grey coat of lichens. Pieces bearing moss are also quite common. Between the patches of lichen may be seen a smooth, dark purplish-brown cork marked with lighter coloured, transversely elongated lenticels. On scraping the cork no bright purple inner cork is disclosed (distinction from *R. Frangula*). The inner surface is dull purplish-brown to black, striated longitudinally, and somewhat corrugated transversely. The fracture is short and granular in the outer part, but somewhat fibrous in the phloem. In the yellowish-brown cortex and phloem lighter groups of sclerenchymatous cells and bast fibres may be seen with a lens. They may be made more distinct by staining with phloroglucinol and hydrochloric acid. Odour, slight; taste, bitter.

Microscopical Characters.—A transverse section of cascara bark (Fig. 150) shows a partial coat of whitish lichen, some ten or more rows of cork cells with reddish-brown contents, and a cortex consisting of collenchyma, parenchyma, and large groups of sclerenchymatous cells. The latter are also found in the outer part of the phloem. The phloem consists of numerous alternating zones of hard and soft bast.

The cortex contains chloroplasts and small starch grains produced by them. Many of the parenchymatous cells contain a yellow substance, which is coloured violet by alkalis. Rosette crystals of calcium oxalate are abundant, and cells containing prisms of calcium oxalate form a sheath round the bast fibres. The latter are best seen in longitudinal section or in the powder. The sieve tubes are best observed after staining the callus of the obliquely-placed sieve plates by means of *Alkaline Solution of Corallin*. Fragments of moss leaves are usually found in the powder (see p. 110).

Constituents.—Cascara contains emodin and other anthraquinone derivatives, but our knowledge of the latter is very incomplete. Gunton and Beal (1922) found 3.81 per cent. of total anthraquinones of which 1.11 per cent. were in the free state. In frangula bark the same workers found 3.77 per cent. and 1.14 per cent. respectively of total and free anthraquinones. Glycosides, apparently analogous to those of frangula bark, have been reported but do not appear to have been obtained in a pure state.

The unmatured drug has a more griping effect than that which has been stored. Meier and Le Roy Webber (1888) suggested that this undesirable effect is produced by an

enzyme which exhausts itself during storage, but it seems more reasonable to suppose that the enzyme brings about some change resembling that of the conversion of glucofrangulin into frangulin. The glucose reported to be present may be formed in this way. No chemical difference has, however, been shown between one-year-old bark and that which has been stored for three years, but a thorough chemical examination of bark stabilised immediately after collection might be more successful.

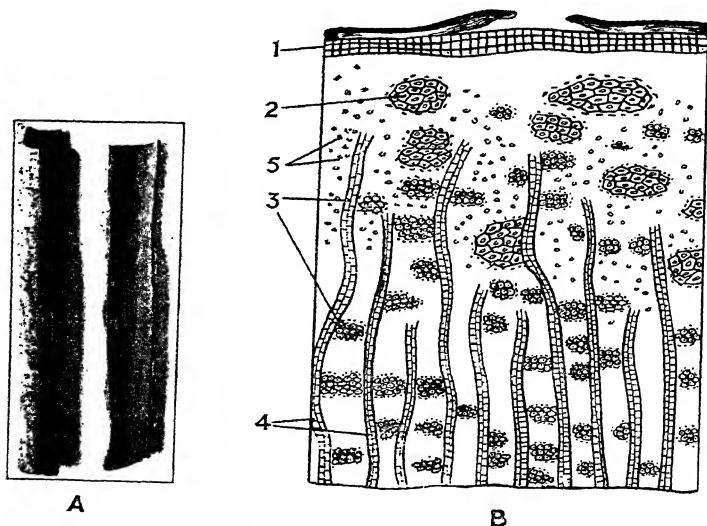


FIG. 150.—A, bark of *Rhamnus Purshiana*; B, transverse section of same. 1, lichens and cork; 2, group of sclerenchymatous cells; 3, groups of bast fibres; 4, medullary rays; 5, crystals of calcium oxalate. (A Newman, B after Gilg.)

The bitter taste is much reduced by treating cascara extracts with alkalis, alkaline earths, or magnesium oxide (cf. Elixir of Cascara Sagrada B.P.). This is said to be due to the conversion of a bitter lactone into less bitter salts. The drug yields about 27 per cent. of aqueous extract and 5 per cent. of ash.*

* Recent samples of Kenya drug have yielded 25.3 to 27.2 per cent. of aqueous extractive and 4.7 to 7.6 per cent. of ash.

Substitutes.—Several species of *Rhamnus* have a similar geographical distribution to that of *R. Purshiana*. These include *R. alnifolia*, which is too rare to be a likely substitute, *R. crocea*, whose bark bears little resemblance to the official drug, and *R. californica* Esch. The latter is so closely related to *R. Purshiana* that some botanists do not divide them into separate species. The plant appears to have a much more southerly distribution than the typical *R. Purshiana* and is therefore unlikely to occur in bark of Canadian origin. It has a more uniform coat of lichens and wider medullary rays than the official species, but resembles the latter in having sclerenchymatous cells. Details of a colour test for distinguishing this species are given in the U.S. Dispensatory.

Uses.—Cascara is a valuable laxative. Large doses, however, are said to produce an inflammatory condition of the bowel.

RHAMNI FRANGULÆ CORTEX

Alder Buckthorn Bark, Frangula Bark ; F. Écorce de Bourdaine ; G. Faulbaumrinde

Source.—Alder buckthorn bark is obtained from *Rhamnus Frangula*, a shrub from 3 to 5 metres high found in Britain and Europe. The plant differs from the common buckthorn, *R. cathartica*, in that it does not possess thorns ; it bears dark purple berries, which have long been used in medicine.

Characters.—The bark occurs in single or double quills which are usually of smaller size than those of cascara and about 0.5 to 1 mm. thick. It has a purplish cork and whitish lenticels. On removing the outer cork cells by scraping a dark crimson inner cork is exposed. The transverse section closely resembles that of cascara, but groups of sclerenchymatous cells are absent.

Constituents.—Casparis and Maeder (1925) isolated about 6 per cent. of an amorphous rhamno-glucoside, glucofrangulin, which appears to lose glucose during the drying and storage of the drug. Its decomposition product, frangulin, has long been known as a constituent of the bark. Frangulin is a rhamnoside which occurs in yellow needles (m.p. 228° to 230°). On hydrolysis it yields rhamnose and frangula-emodin (emodin),

1 : 6 : 8-trihydroxy-3-methylantraquinone. The complete hydrolysis of glucofrangulin may be represented :—

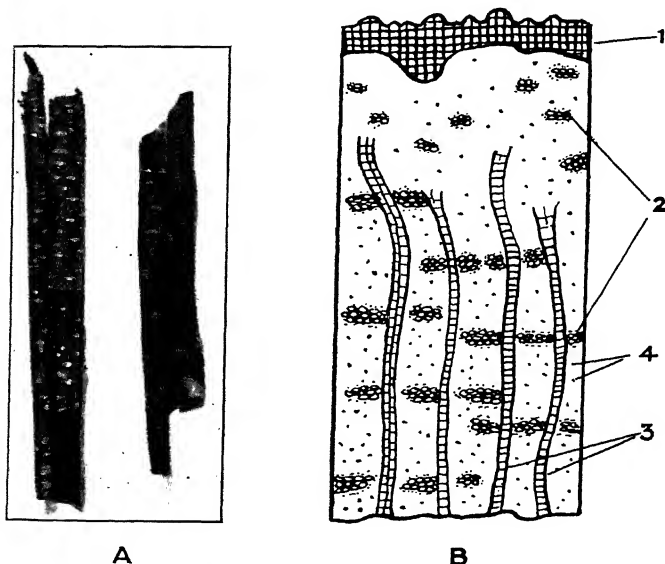
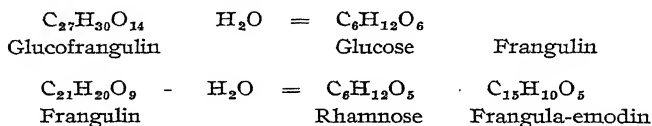


FIG. 151.—A, bark of *Rhamnus Frangula* ; B, transverse section of same. 1, cork; 2, bundles of bast fibres; 3, medullary rays; 4, crystals of calcium oxalate. (A Newman, B after Gilg.)

Frangulin and frangula-emodin do not appear to be sufficiently active to account for the full laxative action of the drug. Frangula bark when fresh is a gastro-intestinal irritant and may produce vomiting, but loses this property on drying and storage. It is rather more pleasant in taste than cascara, but less certain in its action.

Allied Drugs.—The common buckthorn, *R. cathartica*, has a glossy reddish- or greenish-brown cork and does not possess stone cells. It contains frangula-emodin and a glycoside,

rhamnicoside, which yields on hydrolysis rhamnicogenol (an anthraquinone derivative), glucose and xylose (Bridel and Chareux, 1924). It also contains a fluorescent substance.

The bark of *R. carniolica* has a dull reddish cork and differs from frangula bark in that it possesses sclerenchymatous cells and has wider medullary rays.

Order ROSALES

A large order including the families Crassulaceæ, Saxifragaceæ, Hamamelidaceæ, Rosaceæ, and Leguminosæ. The flowers are usually hermaphrodite (rarely bisexual by abortion, e.g. koussou flowers); hypogynous, perigynous, or epigynous. The sepals and petals are usually free; stamens and carpels free or united.

Family HAMAMELIDACEÆ

A family of about 18 genera and 50 species of trees and shrubs. The Witch Hazel is commonly cultivated for its showy yellow flowers.

HAMAMELIDIS FOLIA

Hamamelis, B.P.; Witch Hazel Leaves; F. Feuilles de *Hamamelis de Virginie*; G. *Hamamelisblätter*

Source.—*Hamamelis* consists of the dried leaves of *Hamamelis virginiana*, a shrub or small tree from 2 to 5 metres in height which is widely distributed in Canada and the U.S.A.

Macroscopical Characters.—The leaves are shortly petiolate, 7 to 15 cm. long, and broadly oval to ovate in shape; base asymmetrically cordate, apex acute. The lamina is dark brownish-green to green in colour, and very papery in texture. The venation is pinnate and the margin crenate or sinuate-dentate. The veins are very conspicuous on the lower surface; they leave the midrib at an acute angle and run straight to the margin where they terminate in a marginal crenation. Odour, slight; taste, astringent and bitter.

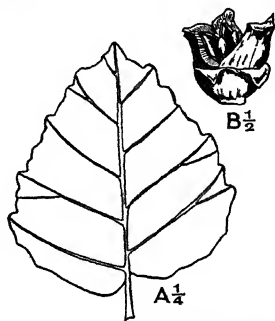


FIG. 152. — *Hamamelis virginiana*. A, leaf; B, fruit. (B after Sargent).

Microscopical Characters.—The drug has very distinctive microscopical characters. These include characteristic stomata present on the lower surface only, very large lignified idioblasts, crystal cells accompanying the pericyclic fibres, tannin containing cells and, especially in young leaves, stellate hairs. The calcium oxalate is in monoclinic prisms 10 to 35μ long.



FIG. 153.—A commercial hamamelis leaf (Newman).

The stellate hairs consist of 4 to 12 cells united at the base. Each cell is thick-walled and up to 500μ in length.

Constituents.—The constituents of the leaves have not been as completely investigated as those of witch-hazel bark. Both drugs on extraction with alcohol yield a tannin-containing dry extract known as "hamamelin." Colour tests indicate the presence of a gallitannin, free gallic acid, and a phlobatannin. The gallitannin of witch-hazel, which is

known as hamamelitannin, has been prepared in a crystalline form (Freudenberg, 1919). It appears to be derived from gallic acid and a sugar related to the hexoses (Freudenberg and Peters, 1920).

When fresh hamamelis leaves are distilled with water the distillate has a distinct aroma, which is probably due to some decomposition product.

Uses.—Hamamelis owes its astringent and hæmostatic properties to the tannins. An extract is therefore a more active preparation than one prepared by distillation.

Allied Drug.—Hamamelis bark occurs in curved or channelled pieces which seldom exceed 10 cm. in length or 2 cm. in width. The bark is silvery grey and smooth, or dark grey and scaly. The inner surface is pinkish and often bears fragments of whitish wood. Sections show a cortex containing prismatic crystals of calcium oxalate, a complete ring of sclerenchymatous cells, and groups of bast fibres. The bark contains about 6 per cent. of tannin, consisting of crystalline hamamelitannin and smaller quantities of amorphous phlobatannin and free gallic acid.

STYRAX

Styrax, B.P. ; *Prepared Storax* ; *Storax* ; F. *Styrax*
Liquide ; G. *Flüssiger Storax*

Source.—*Storax* is a balsam obtained from the wounded trunk of *Liquidambar orientalis*, and subsequently purified. All the species of *Liquidambar* and of the related genus *Altingia* yield balsams, but the most esteemed is that obtained from the above species, a tree up to 14 metres in height found in the south-west of Asia Minor.

Collection and Preparation.—The stems normally possess resin ducts of schizolysigenous origin in the pith near to the protoxylem groups, but none are present in the bark. It has been shown by Moller and Planchon (1896) that as a result of injury schizolysigenous ducts and cavities are produced in the new wood and that the balsam permeates from these into the bark. The drug is, therefore, of purely pathological origin.

In the early summer the bark is injured by bruising or by making incisions. This causes the cambium to produce new wood with balsam-secreting ducts and cavities. After a time

the outer bark may be pared off, or the whole bark may be left until the autumn, when it is removed. The pieces of bark are pressed in horse-hair bags, first in the cold and again after steeping in hot water. Sometimes the bark is boiled with water and again pressed. The exhausted bark is used in the East for fumigation. The crude or liquid storax is exported in casks from Smyrna or other convenient ports.

Storax of the Pharmacopœia is obtained by dissolving the crude balsam in alcohol, filtering, and recovering the solvent at as low a temperature as possible so as not to lose any of the volatile constituents. The alcohol-insoluble matter consists of vegetable debris and a resin.

Characters.—*Crude storax* is a greyish, viscous liquid with a pleasant odour and bitter taste. It usually contains about 20 to 30 per cent. of water. About 82 to 87 per cent. is alcohol-soluble.

Purified storax forms a brown, viscous, semi-solid mass which loses not more than 5 per cent. of its weight when dried on a water bath for one hour. It is completely soluble in alcohol and in ether. Storax has a characteristic balsamic odour and taste.

Constituents.—Storax is very rich in free and combined cinnamic acid. After purification it yields from 30 to 47 per cent. of total balsamic acids. The Pharmacopœia should be consulted for the method of estimating these and for the acid value and other chemical constants.

By steam distillation storax yields an oily liquid containing phenylethylene (styrene), $C_6H_5.CH:CH_2$, cinnamic esters, vanillin, and free cinnamic acid. The resinous portion of the drug consists of steresinol, an amorphous, white substance, which is present both free and combined with cinnamic acid. According to Evers,* “A good specimen of storax contains about 23 per cent. of free cinnamic acid, 22 per cent. of aromatic esters, 2 per cent. of vanillin and styrene, and 36 per cent. of resin.”

The presence of cinnamic acid in the drug is shown by boiling with a solution of potassium dichromate and sulphuric acid, when an odour of benzaldehyde is noticed.

Allied Drug.—American storax or sweet gum resembles the official storax in constituents. It is obtained from *Liquidambar styraciflua* grown in the U.S.A. It is employed in that country

* Evers, *The Chemistry of Drugs* (1933), p. 188.

and was in considerable demand during the war when the Turkish drug was not available.

Uses.—Storax is chiefly used in the preparation of Friar's Balsam.

Family ROSACEÆ

A family which includes about 90 genera and 2,000 species of herbs, shrubs, and trees. The leaves are simple (*e.g.* *Prunus*) or compound (*e.g.* *Rosa*). Considerable variety exists in the flowers and fruits. There are no anatomical features characteristic of the family as a whole, and the various sub-families frequently show differences in stomatal arrangement, origin of cork, etc.

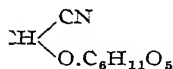
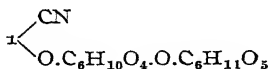
The occurrence of saponins and cyanogenetic glycosides is noteworthy. The latter yield hydrocyanic acid under the influence of enzymes present in the plant. The following scheme showing the relationship of some cyanogenetic glycosides may be found useful :—

Glycosides of benzaldehyde cyanohydrin or mandelonitrile $C_6H_5 \cdot CH \begin{matrix} \diagup CN \\ \diagdown OH \end{matrix}$

Series I

Series II

Formula—



(a) Derived from
l-mandelonitrile*

Amygdalin *partial*

Prunasin + Glucose

Isomerisation

hydrolysis

Isomerisation

(b) Derived from
dl-mandelonitrile

Isoamygdalin

enzyme in

Prulaurasin + Glucose

Fractional crystallisation

yeast extract

Isomerisation

(c) Derived from
d-mandelonitrile

d-amygdalin

Sambunigrin + Glucose

* *d*-mandelonitrile is the nitrile of *d*-mandelic acid and *l*-mandelonitrile the nitrile of *l*-mandelic acid. It so happens that *d*-mandelonitrile is laevorotatory, a fact which sometimes gives rise to confusion in the nomenclature of these compounds.

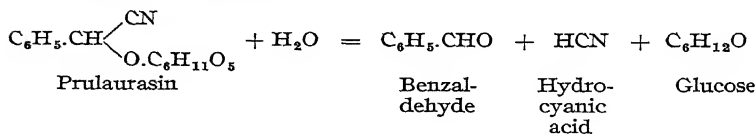
Cyanogenetic glycosides may be detected by the following tests :—

1. Make a fresh solution of guaiacum resin in absolute alcohol; soak filter paper in this and allow to dry. Moisten the filter paper with a very dilute solution of copper sulphate and place on it a freshly exposed surface of the drug. If hydrocyanic acid is evolved a blue stain is produced on the paper. Even drugs such as quince and linseed, which contain little cyanogenetic glycoside, give a distinct reaction.

2. Soak a strip of filter paper in a saturated solution of picric acid; allow to drain thoroughly, dip in a 10 per cent. solution of sodium carbonate and again drain. This paper in the presence of hydrocyanic acid gradually turns brick-red. The drug to be tested is coarsely powdered, mixed with a little water in a flask and the test-paper trapped in the neck by means of a cork. Hydrolysis of the glycoside may be brought about by the enzyme which is usually present or, more rapidly, by the addition of acid.

Cherry-laurel leaves are obtained from *Prunus Lauro-cerasus*, an evergreen shrub common in Europe. They were formerly official in the fresh state. The leaves are petiolate, oblong-lanceolate, and about 12 to 15 cm. long. The margin is recurved and serrated, the serrations being distantly arranged near the base but closer together near the apex. The latter is acuminate and recurved. The leaves are coriaceous; the upper surface is dark green and the lower surface paler. The veins are prominent on the lower surface and near the base of the midrib are from one to five pale green spots (sugar glands), which turn brown when the leaves are dried.

The leaves have little odour when entire but when crushed an odour of benzaldehyde is soon apparent and a positive test for cyanogenetic glycoside is obtained. Prulaurasin, the glucoside of *dl*-mandelonitrile, is present. Its hydrolysis, and also that of prunasin (from *Prunus serotina*) and sambunigrin (from *Sambucus nigra*), may be represented :—



These glucosides are always associated with enzymes capable of bringing about their hydrolysis. The enzyme of

cherry-laurel leaves is known as prunase. It was formerly thought that the glucoside and enzyme were stored in different cells, but Rosenthaler (1922) states that they are contained in the same cells. This is not surprising, since the enzyme is capable of both synthesising and decomposing the glucoside, and conditions in the undamaged plant cell are entirely changed by crushing the leaves. Fresh leaves yield about 0.1 per cent. of hydrocyanic acid.

Prunes are dried plums derived from *Prunus domestica* Linn. Of the many cultivated forms the var. *Juliana* de Candolle, which is largely grown in France, produces those commonly used in European medicine. Prunes of excellent quality are also produced in California.

The appearance of prunes is too well known to require description. The pulp contains about 44 per cent. of sugars (mainly glucose), malic acid and water. The kernel contains 45 per cent. of fixed oil, and small quantities of amygdalin and benzoic acid. Prunes are used in Confection of Senna.

PRUNI VIRGINIANÆ CORTEX

Prunus Serotina, B.P.; Wild Cherry or Virginian Prune Bark; F. *Écorce de Cerisier de Virginie*; G. *Wildkirschenrinde*

Source.—Wild cherry bark is the dried bark of *Prunus serotina* Ehrh. (*P. virginiana* Miller non Linn.*), collected in the autumn, at which time it is most active. The plant is a shrub or tree widely distributed in Canada and the U.S.A., extending from Ontario to Florida and westward to Dakota and Texas.

History.—The drug was introduced into American medicine about 1787 and first appeared in the U.S.P. in 1820. It first attracted notice in Britain about 1863.

Collection and Preparation.—The bark is collected in the autumn. Part of the commercial drug consists of bark which has had the thin outer corky layers ("borke") removed, while part is unpeeled. These varieties are known as "rossed" and "unrossed" bark respectively. Root bark, which is even

* *P. serotina* is the black cherry of America, but collectors sometimes mistake for it the choke cherry, *P. virginiana* Linn.

more active than the stem bark, is also collected. The bark should be thoroughly dried and kept, if possible, in airtight containers.

Macroscopical Characters.—The drug usually occurs in curved or channelled pieces up to 10 cm. in length, 5 cm. in width, and from 0.3 to 3.0 mm. in thickness (Fig. 154). Much larger pieces of trunk bark, up to 8 mm. in thickness, may be met with but the thinner bark is preferred. The branch bark, if

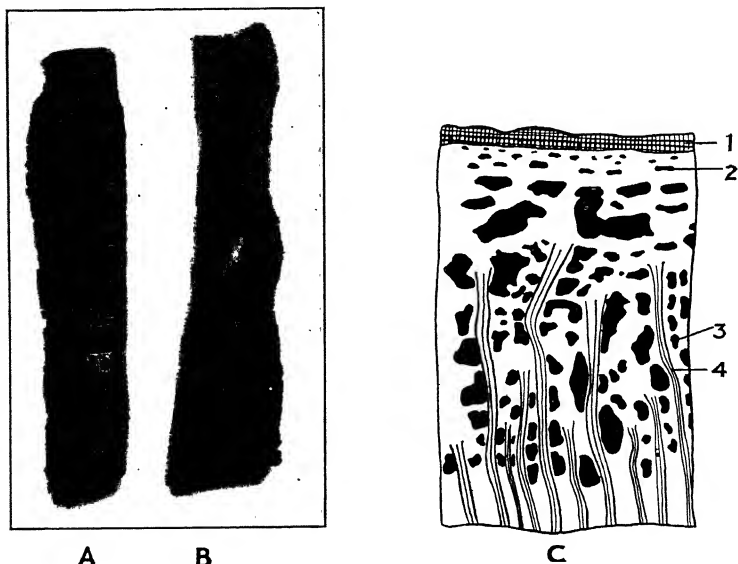


FIG. 154.—Bark of *Prunus serotina*. A, outer surface; B, inner surface; C, transverse section. 1, cork, 2, stone cells of the primary bark; 3, stone cells of the secondary bark; 4, medullary ray. (C after Thoms, *Handbuch der Pharmazie*.)

unrossed, is covered with a thin, glossy, easily exfoliating, reddish-brown to brownish-black cork, which bears very conspicuous whitish lenticels. In the rossed bark pale buff-coloured lenticel scars are seen and the outer surface is somewhat rough, some of the cortex having been removed and the phloem exposed. The inner surface is reddish-brown and has

a striated and reticulately furrowed appearance, which is caused by the distribution of the phloem and medullary rays. Patches of wood sometimes adhere to the inner surface. The drug breaks with a short, granular fracture. When slightly moist it has an odour of benzaldehyde. Taste, astringent and bitter.

Microscopical Characters.—The outermost region consists of numerous layers of very small cork cells. Groups of sclereids, the elements of which are often branched, occur in the primary and secondary cortex and in the phloem. A few pericyclic fibres are present but typical phloem fibres are absent. The sieve tissue is largely obliterated. Small starch grains occur in the outer chlorophyll-containing parenchyma. Prisms of calcium oxalate are abundant in the neighbourhood of the sclerenchymatous groups; occasional cluster crystals are also found.

Constituents.—Perot (1852) obtained from the fresh bark 0.05 per cent. of hydrocyanic acid in April, 0.1 per cent. in June, and 0.14 per cent. in October. The commercial bark yields about 0.075 to 0.16 per cent. This is produced from the glucoside prunasin (*l*-mandelonitrile glucoside) by the action of an enzyme prunase. Each molecule of glucoside yields one molecule each of glucose, benzaldehyde, and hydrocyanic acid.

The bark also contains resins, one of which yields the fluorescent principle scopoletin on hydrolysis; benzoic acid and volatile oil, probably produced from prunasin; *p*-coumaric acid, and trimethylgallic acid. The drug yields 3 to 6 per cent. of ash.

Uses.—Wild cherry is mainly used in cough preparations, to which it gives mild sedative properties and a pleasant taste.

OLEUM AMYGDALÆ EXPRESSUM

Oleum Amygdalæ, B.P. ; Almond Oil ; F. Huile d'Amandes ; G. Mandelöl

Source.—Almond oil is a fixed oil obtained by expression from the seeds of *Prunus communis* Arcang var. *dulcis*

more active than the stem bark, is also collected. The bark should be thoroughly dried and kept, if possible, in airtight containers.

Macroscopical Characters.—The drug usually occurs in curved or channelled pieces up to 10 cm. in length, 5 cm. in width, and from 0.3 to 3.0 mm. in thickness (Fig. 154). Much larger pieces of trunk bark, up to 8 mm. in thickness, may be met with but the thinner bark is preferred. The branch bark, if

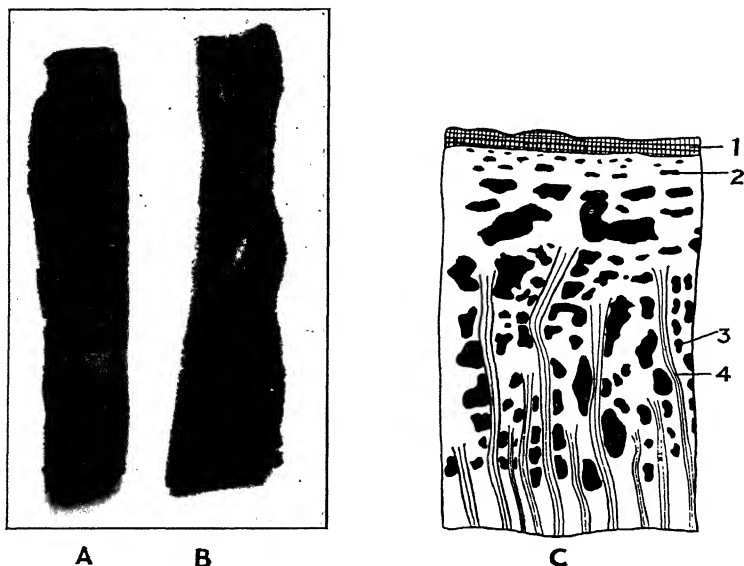


FIG. 154.—Bark of *Prunus serotina*. A, outer surface; B, inner surface; C, transverse section. 1, cork, 2, stone cells of the primary bark; 3, stone cells of the secondary bark; 4, medullary ray. (C after Thoms, *Handbuch der Pharmazie*.)

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The bark also contains resins, one of which yields the fluorescent principle scopoletin on hydrolysis; benzoic acid and volatile oil, probably produced from prunasin; *p*-coumaric acid, and trimethylgallic acid. The drug yields 3 to 6 per cent. of ash.

Uses.—Wild cherry is mainly used in cough preparations, to which it gives mild sedative properties and a pleasant taste.

OLEUM AMYGDALÆ EXPRESSUM

Oleum Amygdalæ, B.P.; *Almond Oil*; F. *Huile d'Amandes*; G. *Mandelöl*

Source.—Almond oil is a fixed oil obtained by expression from the seeds of *Prunus communis* Arcang var. *dulcis*

Schneider (sweet almonds), or *P. communis*, var. *amara* (bitter almonds). The oil is mainly produced from almonds grown in the countries bordering the Mediterranean (Sicily, Italy, France, Spain, and N. Africa).

Characters of Plants and Seeds.—Almond trees are about 5 metres in height and the varieties, apart from differences in the seeds, are almost indistinguishable. The young fruits have a soft, felt-like pericarp, the inner part of which gradually becomes sclerenchymatous as the fruit ripens to form a pitted endocarp or shell. The shells, consisting mainly of sclerenchymatous cells, are often ground and used to adulterate powdered drugs.

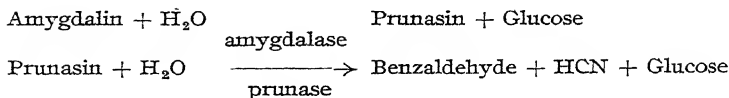
The sweet almond is 2.0 to 3.0 cm. in length, rounded at one end and pointed at the other. The bitter almond is 1.5 to 2 cm. in length but of similar breadth to the sweet almond. Both varieties have a thin, cinnamon-brown testa, which is easily removed after soaking in warm water, a process which is known as blanching. The Jordan or Malaga almonds have a thinner and less scurfy testa than those of Valencia, Sicily, and N. Africa, which approach more closely in shape to bitter almonds. The oily kernel consists of two large, oily, plano-convex cotyledons, and a small plumule and radicle, the latter lying at the pointed end of the seed. Some almonds have the cotyledons of unequal sizes and irregularly folded. Bitter almonds are sometimes found in samples of sweet almonds, particularly those of African origin; their presence may be detected by the guaiacum resin test for cyanogenetic glycosides (p. 458).

Constituents.—Both varieties of almond contain from 40 to 55 per cent. of fixed oil, about 20 per cent. of proteins, mucilage, and emulsin. The bitter almonds contain in addition about 2.5 to 4.0 per cent. of the colourless, crystalline, cyanogenetic glycoside, amygdalin.

Extraction of Oil.—*Almond oil* is obtained by grinding the seeds and expressing them in canvas bags between slightly heated iron plates. They are sometimes blanched before grinding, but this does not appear to be of any particular advantage. The oil is clarified by subsidence and filtration.

Essential or volatile oil of almonds is obtained from the cake left after expressing bitter almonds. This is macerated with water for some hours to allow hydrolysis of the amygdalin to take place. The benzaldehyde and hydrocyanic acid are then separated by steam distillation. Amygdalin is decomposed

in two stages by the enzymes amygdalase and prunase found in emulsin :



Characters and Constituents of Almond Oil.—Almond oil is a pale yellow liquid with a slight odour and bland, nutty taste. It contains a considerable amount of olein with smaller quantities of the glycerides of linolic and other acids.

For tests for purity the Pharmacopœia should be consulted. The acid mixture used for testing for "kernel oils" is known as Bieber's reagent.

Uses.—Almond oil is used in the preparation of many toilet articles. When taken internally it has a mild, laxative action.

CYDONIÆ SEMINA

Quince Seeds ; F. Pépins de Coing ; G. Quittensamen

Quince seeds are obtained from *Pyrus Cydonia*, a tree cultivated in South Africa, Central Europe, and the Levant.

The seeds are separated from the apple- or pear-shaped fruits and dried. They resemble apple pips and frequently adhere together in masses owing to their surface coating of dried mucilage. The latter is derived from the outer epidermis of the testa.

Quince seeds contain about 20 per cent. of mucilage, 15 per cent. of fixed oil, and a small quantity of a cyanogenetic glycoside and an enzyme which effects its hydrolysis.

The seeds are used as an emulsifying agent and in the preparation of hair-fixing lotions.

QUILLAIÆ CORTEX

Quillaia, B.P. ; Quillaia or Soap Bark, Panama Wood ; F. Écorce de Quillaya ; G. Seifenrinde

Source.—Quillaia bark is the dried inner bark of *Quillaja Saponaria* and of other species of *Quillaja*.* *Quillaja*

* Some of the quillaia bark of commerce is said to be derived from *Q. Pæppigii* Walp. and *Q. Smegmadermos* DC. Microscopical examination undertaken by Cofman-Nicoresti and Tallantyre (1920) showed that the structure resembles that of *Q. Saponaria* so closely that they may well be regarded as varieties of this species.

Saponaria is a tree about 18 metres high found in Chili, Peru, and Bolivia. It has been introduced into India and California. The generic name is derived from the Chilean word *quillean*, to wash, from the use made of the bark.

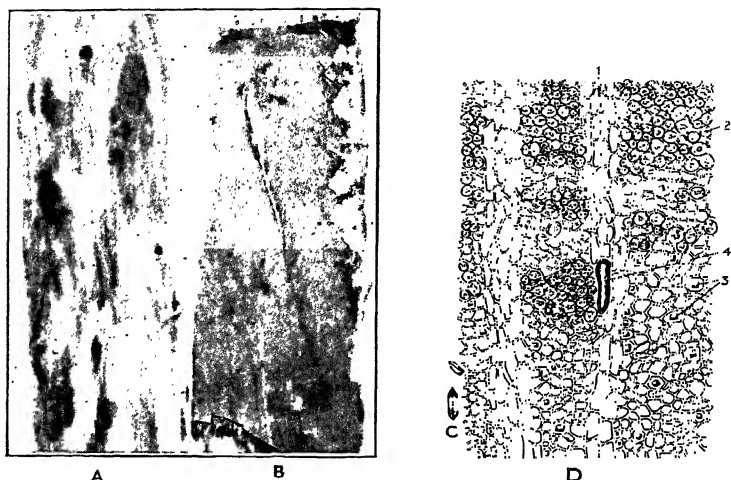


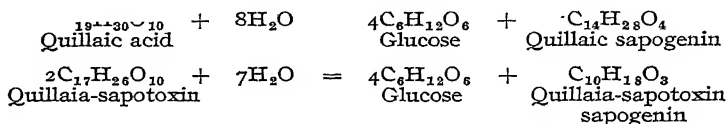
FIG. 155.—*Quillaia Saponaria* bark. A, outer surface; B, inner surface; C, crystals of calcium oxalate; D, transverse section. 1, medullary ray; 2, bast fibres; 3, calcium oxalate; 4, stone cell. (C and D after Gilg.)

Macroscopical Characters.—*Quillaia* bark (Fig. 155) occurs in flat strips about 1 metre long, 20 cm. broad, and 3 to 10 mm. thick. It consists almost entirely of phloem, the outer region in which successive cork cambia develop having been more or less completely removed. A few, reddish- or blackish-brown patches of rhytidome adhere to the outer surface, which is otherwise of a brownish-white colour and reticulated. The inner surface is yellowish-white and fairly smooth. The bark breaks with a splintery fracture and is inclined to laminate (between the zones of hard and soft bast). Large crystals of calcium oxalate may be seen with the naked eye. The powdered drug is very sternutatory and produces an abundant froth when shaken with water. Taste, acrid and astringent.

Microscopical Characters.—A transverse section of *quillaia* bark has a chequered appearance which is caused by the

crossing of the medullary rays by alternating bands of hard and soft bast. The medullary rays are usually two to four cells wide. The bast fibres are tortuous and often accompanied by small groups of rectangular stone cells. The parenchyma contains numerous starch grains up to 20μ in diameter and single crystals of calcium oxalate up to 160μ in length.

Constituents.—Quillaia contains an acid saponin, quillaic acid, and a neutral saponin, quillaia-sapotoxin. Commercial "saponin" is a more or less impure mixture of these substances. It dissolves in water but on boiling the solution with a little acid the saponins are hydrolysed and a precipitate of the sparingly soluble sapogenins forms. The hydrolysis has been represented :



The drug also contains sugars, starch, and calcium oxalate. It yields not more than 15 per cent. of ash.

Varieties.—In addition to the typical quillaia described above, a variety in quills and another in thin strips with a very reticulated surface have been imported. Whether these are derived from varieties of *Q. Saponaria* or from distinct species is at present unsettled.

Uses.—Quillaia is used as an emulsifying agent, particularly for tars.

OLEUM ROSÆ

*Oil of Rose, Otto or Attar of Rose ; F. Essence de Rose ;
G. Rosenöl*

Source.—Oil of rose is a volatile oil obtained by distillation from the fresh flowers of the damask rose, *Rosa damascena*. The chief producing country is Bulgaria, but smaller quantities are prepared in the South of France and in Germany.

Preparation.—The oil is prepared in copper alembic stills by the peasants or in large factories under careful scientific control. Some 3,000 parts of flowers yield only one part of oil. The oil is very expensive and very liable to adulteration. The "peasant distilled" oil usually fetches a lower price than

that produced in the larger works. The oil is exported in handsome metal "vases" covered with felt, ribbon in the Bulgarian colours, and customs seals.

Characters and Constituents.—The oil is a pale yellow semi-solid. The portion which is solid at ordinary temperatures forms about 15 to 20 per cent. and consists of odourless stearoptene. The liquid portion forms a clear solution with 70 per cent. alcohol. It consists of the sesquiterpene alcohols geraniol and citronellol, with smaller quantities of esters and other odorous principles. Although the alcohols form about 70 to 75 per cent. of the oil the odour is so modified by the other constituents that no artificial mixture of the known constituents can be made to reproduce the odour of the natural oil.

Uses.—Oil of rose is of great importance in perfumery and students should endeavour to supplement the above brief account of the oil from one of the books specially dealing with perfumery products.

Family LEGUMINOSÆ

The Leguminosæ is the second largest family of flowering plants and contains 550 genera and over 12,000 species. The family includes more important drugs than any other. It is divided into three subfamilies, the Papilionaceæ, Mimosoideæ, and Cæsalpinioidæ.

Subfamily Papilionaceæ.—Herbs, shrubs, or trees; leaves simple or compound; the flowers are zygomorphic and papilionaceous, *e.g.* in broom, *Cytisus scoparius*; stamens ten, monadelphous or diadelphous; fruit a legume. Important drugs, which are described below, are Calabar beans, tonco beans, liquorice, derris, arachis oil, kino, araroba, balsam of Tolu, balsam of Peru, and tragacanth. The following will not be described: * soja bean oil (*Glycine Soja*), fenugreek seeds (*Trigonella Fœnum-grædum*), prayer beads (*Abrus precatorius*), indigo (*Indigofera tinctoria*), butea seeds (*Butea frondosa*), and mucuna or cowhage (*Mucuna pruriens*). Red sanders wood, although derived from a member of this subfamily, may be conveniently referred to under logwood (Cæsalpinioidæ).

* More advanced students may supplement their knowledge by studying these drugs from the *British Pharmaceutical Codex*, *U.S. Dispensatory*, or similar works.

Subfamily **Mimosoideæ**.—Most of the members are trees or shrubs; leaves usually bipinnate; flowers regular; calyx usually gamosepalous; stamens equal in number to the petals, or twice as many, or numerous; fruit a legume. The only important drug obtained from the subfamily is acacia gum. Acacia barks (*Acacia arabica* and *A. decurrens*) are used in tanning, and oil of cassie (*A. Farnesiana*) in perfumery.

Subfamily **Cæsalpinioidææ**.—Most of the members are trees or shrubs; leaves pinnate or bipinnate; flowers zygomorphic; typical floral formula $K_5, C_5, A_{5+5}, G_{\overline{1}}$; fruit a legume or lomentum. The number of the petals and stamens is often reduced, e.g. in *Krameria triandra* the anterior pair of petals are modified into fleshy glands and there are only three stamens, while in *Copaifera* the corolla is entirely absent. Important drugs derived from the subfamily are senna leaves and pods, cassia and tamarind fruits, logwood and sappan woods, krameria root and copaiba. Of less importance are sassy bark (*Erythrophleum guineense*), carob beans (*Ceratonia siliqua*), and “rouge et noir” beans (*Afzelia* spp.)

The following anatomical features may be noted:—Tannin sacs are common, particularly in the Mimosoideæ and Cæsalpinioidææ. Simple hairs such as are found in senna are common in the Cæsalpinioidææ and Mimosoideæ, but in the Papilionaceæ the typical form of hair is a uniseriate one possessing one or more short basal cells and a long terminal one. Several different types of stoma occur, but that found in senna with two subsidiary cells parallel to the pore is very common. Such stomata may be described as rubiaceous.

The broom, *Cytisus scoparius*, is a perennial shrub about 1 to 2 metres high. The lower part is woody, but the long, straight branches are green and glabrous. The upper parts of the stem bear five prominent, longitudinal ridges. The lower leaves are stalked and consist of three obovate leaflets, but the upper leaves are sessile and usually reduced to a single leaflet.

The flowers are typical of the subfamily Papilionaceæ. They have the floral formula $K(5), C_3+(2), A_{10}, G_{\overline{1}}$. The large posterior petal is known as the standard, the lateral ones as the alæ or wings, and the united anterior pair as the keel. The fruit is a black, hairy pod about 3 to 5 cm. in length. The seeds are liberated when ripe by the sudden dehiscence and twisting of the two valves of the pod. Each seed bears a caruncle.

Broom tops were formerly official. Their chief constituents

are a volatile liquid alkaloid, sparteine, and a yellow flavone, scoparin. The drug is now seldom used.

PHYSOSTIGMATIS SEMINA

*Calabar or Ordeal Beans ; F. Fève du Calabar ;
G. Kalabarbohne*

Source.—Calabar beans are the dried ripe seeds of *Physostigma venenosum*, a perennial woody climber found on the banks of streams in West Africa. The plant bears typical papilionaceous flowers, and legumes about 15 cm. long each containing two or three seeds.

History.—The seeds were formerly used by the West African tribes as an “ordeal poison.” They were first known

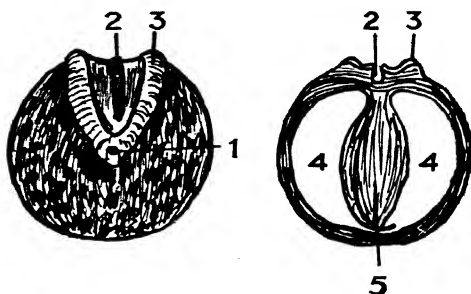


FIG. 156.—Seeds of *Physostigma venenosum* seen from micropylar end and in transverse section. 1, micropyle; 2, hilum; 3, ridge; 4, cotyledon; 5, cavity. (After Tschirch.)

in England in 1840. The myotic effect of the drug was noted in 1862 by Fraser, and the alkaloid physostigmine isolated in 1864 by Jobst and Hesse.

Characters.—Calabar beans (Fig. 156) have a somewhat flattened, reniform shape. They are 15 to 30 mm. long, 10 to 15 mm. wide and up to 15 mm. thick. The seeds are extremely hard. The dark brown testa is smooth except in the neighbourhood of the grooved hilum, which runs the whole length of the convex side and round one end, where it is somewhat wrinkled. On either side of the groove is a well-marked ridge and in the groove itself are the greyish, papery remains of the funiculus. A transverse section shows a

large central cavity and two, very hard, concavo-convex cotyledons.

Constituents.—The following alkaloids have been isolated from the drug :—Physostigmine or eserine (1864), eseramine (1893), isophysostigmine (1904), physovenine (1911), and geneserine (1915). The chief alkaloid, physostigmine, is present to the extent of about 0.15 per cent. Physostigmine is a crystalline, monoacidic tertiary base. On exposure to air it oxidises into a red compound, rubreserine, and should therefore be protected from air and light. The official salt, the salicylate, is more stable than the sulphate and is non-deliquescent.

The seeds also contain sterols (stigmasterol and sitosterol), dihydric alcohols and starch.

Uses.—Physostigmine salicylate is used in the form of an eye ointment or as lamellæ for contracting the pupil of the eye.

TONCO SEMINA

*Tonco, Tonka, or Tonquin Beans ; F. Fève Tonka ;
G. Tonkabohnen*

Source.—Tonco beans are the dried seeds of *Dipteryx odorata* Willd. (*Coumarouna odorata* Aubl.) and *Dipteryx oppositifolia*. The former plant is a native of Guiana and Brazil and is extensively cultivated in Venezuela, while the latter is found in Guiana and Northern Brazil. Both are large trees bearing single-seeded fruits about 3 to 5 cm. long.

Collection and Preparation.—The fruits are collected when ripe (May and June), opened, and the seeds dried in the sun. If sold without further treatment, they are known as "black" beans. The seeds produced in Venezuela and near its border are larger than those produced in Northern Brazil and parts of the Guianas. The former, which are most esteemed, are known as "Angostura" and the latter as "Para" beans.

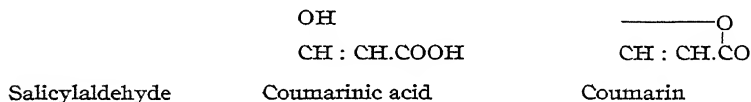
Large quantities of both Angostura and Para beans are sent to Trinidad, where they are macerated for twenty-four hours in rum and dried in the open air. This treatment causes a crystalline deposit of coumarin to be formed on the testa and the seeds are said to be "frosted." Angostura and Para beans thus occur in commerce both black and frosted.

Characters.—Tonco beans are up to 40 mm. long, 10 mm. wide, and 5 mm. thick. They are rounded at one end and bluntly pointed at the other. The surface is black and deeply

wrinkled longitudinally, a crystalline incrustation being present in the frosted variety. A transverse section shows a very thin, black testa and two yellowish-brown, plano-convex, oily cotyledons. Odour, very fragrant; taste, aromatic and bitter.

Constituents.—Tonco beans contain 1 to 3 per cent. of coumarin, 25 per cent. of fat (containing unsaponifiable sitosterin and stigmasterin), and a large amount of starch. Ash about 3.5 per cent.

Coumarin is the lactone of coumarinic (hydroxycinnamic) acid. It may be prepared synthetically from salicyl aldehyde by boiling this with acetic anhydride and anhydrous sodium acetate (Perkin's reaction).



Uses.—Tonco beans are used in tobacco manufacture and in perfumery. Synthetic coumarin has, to some extent, replaced the natural product.

GLYCYRRHIZÆ RADIX

Glycyrrhiza, B.P.; *Liquorice Root*; F. *Racine de Réglisse*; G. *Süßholzwurzel*

Source.—Liquorice consists of the roots and subterranean stems of various species of *Glycyrrhiza*. The plants yielding most of the commercial drug are:

(a) *Glycyrrhiza glabra* var. *typica* Reg. et Herd., a plant about 4 or 5 feet high bearing typical papilionaceous flowers of a purplish-blue colour. The underground portion consists of long roots and thin rhizomes or stolons. The principal root divides just below the crown into several branches which penetrate the soil to a depth of 4 feet or more. A considerable number of stolons are also given off, which attain a length of 5 or 6 feet but run nearer to the surface than the roots. This plant is grown in Spain (Old Castile, Navarra, Aragon, Catalonia, Valencia, and Andalusia), Italy (Calabria and

Sicily), England (Yorkshire), France, Germany, and the U.S.A.

(b) *Glycyrrhiza glabra* var. *β-glandulifera* Reg. et Herd. (*G. glandulifera* Waldstein and Kitaibel), is abundant in the wild state in Galicia and Central and Southern Russia. The underground portion consists of a large rootstock, which bears numerous long roots but no stolons.

(c) *Glycyrrhiza glabra* var. *β-violacea* Boiss., yields the "Persian" liquorice, which is collected in Iran and Iraq in the valleys of the Tigris and Euphrates. As its name implies, it bears violet flowers.

History.—Liquorice is referred to by Theophrastus. The Roman writers referred to it as *Radix dulcis*, but it does not appear to have been cultivated in Italy until about the thirteenth century. Its cultivation in England has been traced back as far as the sixteenth century.

Cultivation and Collection.—In Western Europe liquorice is cultivated, but the Russian and Persian drugs are obtained from wild plants. The plants usually grow well in deep, sandy but fertile soil, near streams. They are usually propagated by replanting young pieces of stolon, but may be grown from seed. The underground organs are developed to a sufficient extent by the end of the third or fourth year, when they are dug up and washed. Large quantities are peeled and cut up into short lengths before drying, but much is used unpeeled. The drug is imported in bales. In Southern Italy and the Levant a large proportion of the crop is made into stick or block liquorice. This is prepared by a process of decoction, the liquid being subsequently clarified and evaporated to the consistence of a soft extract. The latter is made into blocks or sticks, stamped with the maker's name (*e.g.* Solazzi), dried, and exported in cases which often contain bay laurel leaves.

Macroscopical Characters.—The Spanish and Italian drugs are derived from the var. *typica*. They are sold as "Spanish" liquorice irrespective of their exact geographical source. Typical "Spanish" liquorice occurs in straight pieces from 14 to 20 cm. or more in length and from 5 to 20 mm. in diameter. If unpeeled, they have a dark, reddish-brown cork and the runners, which are more numerous than the roots, bear buds. The peeled drug has a yellow, fibrous exterior. Fracture, fibrous. Odour, faint but characteristic; taste, sweet and almost free from bitterness.



FIG. 157.—Portion of a dried plant of *Glycyrrhiza glabra* (Sutcliffe).

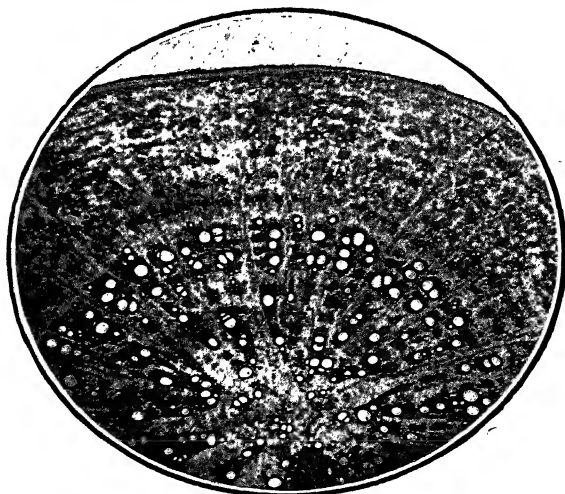


FIG. 158.—*Glycyrrhiza glabra*. Transverse section of a Spanish rhizome showing cork, hard and soft bast, wood with vessels, fibres and wood parenchyma, and pith (Sutcliffe).

Unpeeled *Russian* liquorice occurs in somewhat tapering pieces up to 30 cm. in length and 5 cm. in diameter. It is of less regular appearance than the Spanish and consists of rootstock and roots. The surface is covered with a somewhat scaly, purplish cork. The pieces of rootstock often bear buds and have a pith, but the roots may be distinguished from the stolons of the Spanish drug by the absence of buds. Fracture, very fibrous, the strands of fibres tending to separate from one another. This variety is frequently peeled. The taste is sweet but usually not entirely free from bitterness or acidity. Anatolian, Syrian and "Persian" liquorices closely resemble the Russian variety and are generally unpeeled.

Microscopical Characters.—A transverse section of an unpeeled Spanish runner (Fig. 158) shows about ten rows of narrow cork cells, a parenchymatous cortex, a wide phloem containing alternating zones of hard and soft bast, cambium, wood, and pith. The wood consists of large vessels, groups of fibres and wood parenchyma.

In longitudinal section (Fig. 159) the fibres of both wood and phloem are seen to be surrounded by a sheath of cells containing prisms of calcium oxalate. The vessels are yellow and have pitted or reticulated walls. The parenchyma contains abundant starch (Fig. 159) and a few prisms of calcium oxalate. For powder, see p. 109.

Allied Drug.—*Manchurian liquorice*, which has been imported since the war, is probably derived from *G. uralensis*. It bears a chocolate-brown, exfoliating cork and differs from *G. glabra* in internal structure, the medullary rays being curved and lacunæ present in the wood. It appears to contain about as much glycyrrhizin as the other varieties, but only traces of sugars.

Constituents.—The chief constituent of liquorice is a tri-basic acid, glycyrrhizic acid, $C_{44}H_{64}O_{19}$ or $C_{44}H_{60}O_{18}$, which is present in the drug in the form of glycyrrhizin, its potassium calcium salt.* Glycyrrhizic acid is not a glycoside since it yields on hydrolysis one molecule of glycyrrhetic acid and two molecules of glycuronic acid, but no sugar. Glycuronic acid is, however, very closely related to the hexose sugars, and

* The name "glycyrrhizin" is sometimes applied to a preparation which is more correctly called "Ammoniated glycyrrhizin." This is prepared by extracting liquorice with solution of ammonia; adding acid to the extract and collecting the precipitate; redissolving the latter in ammonia and evaporating to form a scale preparation. See Glycyrrhizinum Ammoniatum, B.P.C.

glycyrrhetic acid has a hæmolytic action like that of the saponins.

Liquorice also contains glucose (up to 3·8 per cent.),

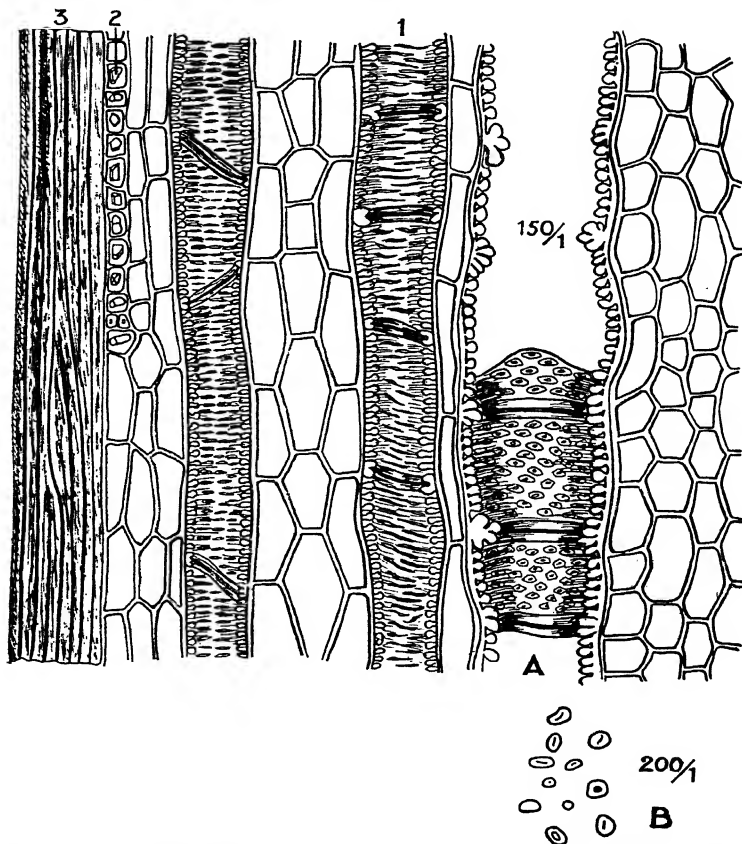


FIG. 159.—A, longitudinal section through the wood of *Glycyrrhiza glabra*. 1, vessel; 2, crystals of calcium oxalate; 3, fibres; B, liquorice starch. (A after Tschirch, B after Greenish.)

sucrose (2·4 to 6·5 per cent.), bitter principles, resins, mannite, asparagine (2 to 4 per cent.), and fat (0·8 per cent.).

Numerous methods have been published for the estimation

of glycyrrhizin, and an accurate process now appears to be available. Some of the earlier processes of estimation gave low results. The following analytical figures are due to Houseman.*

Variety.	Glycyrrhizin, per cent.	Sugars, per cent.	Bitter Principles.		Resins, per cent.
			Water-soluble, per cent.	Water-insoluble, per cent.	
Spanish—Alicante ..	10.06	8.42	3.31	2.58	3.27
„ —Saragossa ..	7.41	4.66	3.05	2.93	2.07
„ —Toledo ..	5.89	5.36	3.38	2.93	2.26
Italian ..	9.18	5.32	3.38	3.78	2.82
Russian ..	9.88	6.75	3.05	2.29	4.12
Anatolian ..	13.24	7.43	3.62	3.52	2.35
Syrian ..	7.44	6.41	3.07	3.08	3.03
Turkish-Arabian ..	8.87	6.92	3.92	4.18	1.75

The official drug yields not less than 20 per cent. of water-soluble extractive. Ash of the peeled drug about 3 to 4 per cent.

Uses.—Most of the liquorice imported is used in the tobacco trade or in confectionery. It is employed in pharmacy as a flavouring agent and as a demulcent and mild expectorant.

DERRIS.

Derris Root ; Tuba Root ; Aker-tuba

Source.—Derris is the dried rhizome and roots of *Derris elliptica* ("Tuba Putih") and *D. malaccensis* ("Tuba Merah"), climbing plants indigenous to Malaya. Other species of *Derris* are also imported.† The increasing demand for derris root has led to large-scale cultivation in Malaya, Ceylon and India. Large supplies of cuttings have been supplied from the Changi district of Singapore, particularly to Japan and the

* Houseman, *Amer. J. Pharm.*, 1912, 531; 1921, 481; Houseman and Lacey, *Indust. and Engin. Chem.*, 1929, 915.

† For details, see Hooper, *Derris as an Insecticide*, C. and D., 1935, Aug. 3, 149.

Dutch East Indies,* whilst the area under cultivation on Singapore Island rose from 750 acres in 1935 to 1350 acres in 1936.†



FIG. 160.—*Derris elliptica*. (From C. and D. by courtesy of Cooper, MacDougall and Robertson, Ltd.)

Characters.—The roots are up to 2 metres in length and 1 cm. or more in diameter. They are sometimes attached to short pieces of rhizome. The outer surface is greyish-brown to reddish-brown and bears fine longitudinal furrows and, in the larger pieces, elongated lenticels. The drug is flexible and breaks with a fibrous fracture. It has a slight aromatic odour, and when chewed gradually produces a feeling of numbness in the tongue and throat. Prolonged grinding of the drug is necessary on account of its fibrous nature, and special precautions are necessary owing to the objectionable properties of the dust. A transverse section shows a thin brown bark and a cream to pale brown wood, which in the larger pieces shows three or four concentric rings.‡

Constituents.—Derris contains up to about 8 per cent. of rotenone, a colourless crystalline substance which is insoluble in water but soluble in many organic solvents. Rotenone is, however, not the only constituent having insecticidal properties, and the evaluation of the drug solely on rotenone-content is therefore unsatisfactory. A satisfactory grade of powdered derris should contain about 4 per cent. or more

* Colonial Report on Straits Settlements in 1935, No. 1783.

† Colonial Report on Straits Settlements in 1936, No. 1812.

‡ For histology, see Worsley and Nutman, *Nature*, 1937, 139, 883.

of rotenone or not less than 15 per cent. of total ether-extractive.*

Allied Drug. *Cubé or Barbasco*.†—The words “cubé” and “barbasco” are applied in Spanish-speaking countries to any fish-poisoning plants, but the drug now cultivated in South America and exported under these names consists of species of *Lonchocarpus*, particularly *L. Nicou*. Cubé, as imported into this country, contains about the same percentages of rotenone and ether-extractive as derris, but figures up to about 18 per cent. of rotenone are quoted in the literature.

OLEUM ARACHIS

Oleum Arachis, B.P.; *Earth-Nut, Ground-Nut, Pea-Nut, or Arachis Oil*; F. *Huile d'Arachide*; G. *Erdnussöl*

Source.—*Arachis* oil is obtained by expression from the seeds of *Arachis hypogæa*, a small annual plant cultivated throughout tropical Africa and in India and Brazil. Enormous quantities of the fruits and seeds are shipped to Marseilles and other European ports for expression.

Preparation.—During ripening the fruits bury themselves in the sandy soil in which the plants grow. Each fruit contains from one to three reddish-brown seeds. The fruits are shelled by a similar machine to that illustrated on p. 37. The thin testas are then detached by brushing, and removed by a blast of air. The kernels contain from 40 to 50 per cent. of oil. Owing to the high oil-content the seeds, when crushed, are somewhat difficult to express. Part of the oil is usually removed by a first expression in the cold, and a further quantity by hot expression. These two fractions differ so little from one another that they are usually mixed. The press cake forms an excellent cattle food. The ground pericarps of earth nuts are a common adulterant of powdered drugs.

Constituents.—*Arachis* oil consists of the glycerides of arachic, stearic, lignoceric, oleic, and other acids. When saponified with alcoholic potassium hydroxide, crystals of impure potassium arachate separate on standing. *Arachis* oil is one of the most likely adulterants of other fixed oils, e.g. olive oil. Its presence may be detected by the test described in the Pharmacopœia.

* See also *Derris Developments* No. 2, 1934, W. Benkert & Co., Inc.

† Roark, *What is Cubé, Soap*, April 1935, 95. See also *Derris and Cubé, Soap*, June 1936, 113.

Uses.—Arachis oil is officially permitted to be used in the preparation of liniments, plasters, etc., when olive oil is not readily available.

KINO

*East Indian, Malabar, Madras, or Cochin Kino ;
F. and G. Kino*

Source.—Malabar kino is a dried juice obtained from the trunk of *Pterocarpus Marsupium*, a large tree grown in Central and Southern India and in Ceylon. Incisions are made which puncture the secretory cells of the phloem, and the juice which exudes is collected in cup-like receptacles. It is often allowed to evaporate spontaneously, but in the preparation of the drug formerly official it was directed that the juice be heated to boiling before being evaporated to dryness.

History.—The term “kino” is a generic one which was first applied to the product obtained from the African tree *Pterocarpus erinaceus*. This was described by Fothergill in 1757. The name has since been applied to a large number of similar products.

Characters.—Malabar kino occurs in small, angular, reddish-black fragments. The surface is fairly free from dust (distinction from *Eucalyptus* kinos), and fragments of cork are absent (distinction from butea gum). Thin flakes are transparent and ruby-red. Inodorous. Taste, very astringent.

The drug is almost completely soluble in 90 per cent. alcohol, and water dissolves about 80 to 90 per cent. of it. On adding a mineral acid to an aqueous solution a dense precipitate of kinotannic acid is obtained. Kino gives the reactions of phlobatannins.

Constituents.—Malabar kino contains variable proportions of kinotannic acid (25 to 80 per cent.) and its decomposition products, “kino-red.” It also contains water, catechol, and gallic acid and, if not boiled, an oxydase enzyme. The latter is capable of causing the gelatinisation of galenicals made from the drug by converting the kinotannic acid into the insoluble phlobaphene, kino-red.

Allied Drugs.—*Butea gum* or *Bengal kino* is the dried juice of *Butea frondosa*. It may be distinguished from Malabar kino by the presence of corky particles and by the fact that it

usually contains less water-soluble matter. The amount of kinotannic acid present is from 15 to 60 per cent.

Red gum or *Eucalyptus kino* is an Australian kino derived from *Eucalyptus rostrata* (Fam. Myrtaceæ). It is covered with a reddish powder but closely resembles the Malabar drug, which, however, occurs in clean glistening fragments almost free from dust. It appears to contain only slightly less kinotannic acid than the Malabar variety.

Uses.—The kinos have marked astringent properties and are used for diarrhoea and dysentery.

CHRYSAROBINUM

Chrysarobinum, B.P.; *Chrysarobin*, *Crude Chrysophanic Acid*,
Purified Araroba

Source.—Chrysarobin is a mixture of substances obtained from araroba or Goa powder by extracting it with hot benzene. Araroba is a substance found in cavities in the trunk of *Andira araroba*, a tree 20 to 30 metres in height found in the Brazilian provinces of Bahia and Sergipe.

Collection and Preparation.—Araroba is formed by the breaking down of the elements of the wood, but the causes of this pathological change are unknown. Old trees contain the largest cavities. The trees are felled and split so that the araroba may be scraped out. It occurs as a yellowish powder, which darkens with age to a chocolate-brown colour. The powder is very irritating to the eyes and face and is often moistened to render it less objectionable to handle. On arrival in this country it is sifted to free it from the larger particles of wood, dried, and powdered.

Chrysarobin is prepared from araroba by extracting it with hot benzene in a Soxhlet apparatus, evaporating the solution to dryness and powdering.

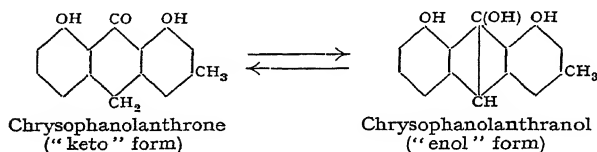
Characters.—Crude araroba, when examined microscopically, shows fragments of wood, prismatic crystals, and amorphous particles. Chrysarobin is a yellowish, microcrystalline powder, which has a very characteristic microscopical appearance.*

Chrysarobin melts on heating, gives off yellow fumes, and leaves not more than 0.5 per cent. of ash. It is almost insoluble in water, but completely soluble in hot chloroform or in hot benzene.

* See Tschirch, *Handbuch der Pharmakognosie*, II, Abt. 2, Fig. 388.

When chrysarobin is boiled with caustic soda or borax solution and the liquid poured into water a well-marked green fluorescence is observed. If a minute quantity is mixed with a drop of fuming nitric acid on a white tile a brownish-red liquid is produced, and on allowing a drop of dilute ammonia solution to mix with it an evanescent violet colour is produced.

Constituents.—According to Eder and Hauser,* the chief constituents of chrysarobin are chrysophanolanthrone or its "enol" form, chrysophanolanthranol (29 to 39 per cent.); emodinanthrone monomethyl ether (18 to 20 per cent.); and dehydroemodinanthrone monomethyl ether (22 to 35 per cent.).



These compounds are closely related to the constituents of rhubarb, senna, and other laxative drugs. Araroba has, in fact, a purgative action but is unsuitable for internal use.

Uses.—Chrysarobin is used in various skin diseases, particularly psoriasis and eczema.

BALSAMUM TOLUTANUM

Balsamum Tolutanum, B.P. ; *Tolu* ; *Balsam of Tolu* ;
F. *Baume de Tolu* ; G. *Tolubalsam*

Source.—Tolu is a balsam obtained by incision from the trunk of *Myroxylon Toluifera* H.B. and K., a large tree which differs but little from that yielding balsam of Peru.† Wild trees are abundant in Colombia and Venezuela, and in the former country large quantities of balsam are produced in the neighbourhood of the Magdalena and Cauca rivers. The trees are cultivated in the West Indies, particularly in Cuba.

History.—Balsam of Tolu was described by Monardes in 1574. The collection was observed by Weir in 1863, and

* Eder and Hauser, *Arch. Pharm.*, 1925, **203**, 321 ; **283**, 436.

† According to Thoms, *Handbuch der Pharmazie*, the two balsams are derived from varieties of *Myroxylon balsamum* (L.) Harms.—balsam of Tolu from the var. *genuinum* Baillon and balsam of Peru from the var. *Periæ* Royle.

flowers, fruits, and seeds were obtained by Goering in 1868. The drug takes its name from a town near Cartagena.

Collection and Preparation.—The young twigs contain schizogenous secretion ducts, but none of these are normally present in the old bark, the commercial balsam being purely pathological in origin. Weir's description is summarised in the *Pharmacographia* as follows:—

“ The balsam tree has an average height of 70 feet with a straight trunk, generally rising to a height of 40 feet before it branches. The balsam is collected by cutting in the bark two deep sloping notches, meeting at their lower ends in a sharp angle. Below this V-shaped cut, the bark and wood is a little hollowed out, and a calabash of the size and shape of a deep tea-cup is fixed. This arrangement is repeated, so that as many as twenty calabashes may be seen on various parts of the same trunk. When the lower part has been too much wounded to give space for any fresh incisions, a rude scaffold is sometimes erected, and a new series of notches made higher up. The balsam-gatherer goes from time to time round the trees with a pair of bags of hide, slung over the back of a donkey, and empties into them the contents of the calabashes. In these bags the balsam is sent down to the ports where it is transferred to the cylindrical tins in which it reaches Europe.”

A portion of trunk showing a gourd cup in position is in the Kew museum and is illustrated by Tschirch.* The drug is mainly exported from Cartagena, Sabanilla, and Sta. Marta.

Characters.—When freshly imported, Tolu is a soft, yellow semi-solid. On keeping it turns to a brown, brittle solid. It softens on warming and if a little be then pressed between two glass slides microscopical examination will show crystals of cinnamic acid, amorphous resin and vegetable debris. Odour, aromatic and fragrant; taste, aromatic, the drug forming a plastic mass when chewed.

An alcoholic solution of the balsam is acid to litmus, and gives a green colour with ferric chloride (the latter possibly owing to the presence of resinotannol). Like other drugs containing cinnamic acid it yields an odour of benzaldehyde when oxidised with potassium permanganate solution.

Constituents.—Tolu contains about 75 to 80 per cent. of resin, benzyl benzoate, benzyl cinnamate, cinnamyl cinnamate, and vanillin, and about 19 to 25 per cent. of free balsamic acids. The resin consists of esters of cinnamic and benzoic acids with the resin alcohol, tolueresinotannol, $C_{17}H_{18}O_5$.

* *Handbuch der Pharmakognosie*, III, Abt. 2, 1031.

Samples analysed by Cocking and Kettle (1918) gave about 36 per cent. of total balsamic acids and 20·8 per cent. of free balsamic acids (8 per cent. free benzoic and 12·8 free cinnamic acid). The present official requirements are less stringent than those of the 1914 Pharmacopœia, being 19 to 25 per cent. of free and 35 to 50 per cent. of total balsamic acids calculated with reference to the dry, alcohol-soluble portion of the drug.

The most likely adulterants of tolu are colophony and balsam which has been exhausted in the preparation of Syrup of Tolu.

Uses.—Balsam of Tolu has antiseptic properties. It is a common ingredient of cough mixtures, to which it is added in the form of syrup or tincture.

BALSAMUM PERUVIANUM

Balsamum Peruvianum, B.P. ; Balsam of Peru ; F. Baume de Pérou ou San Salvador ; G. Perubalsam

Source.—Balsam of Peru is obtained from the trunk of *Myroxylon Pereiræ* (Royle) Klotzsch, after it has been beaten and scorched. The drug is produced in Central America (San Salvador, Honduras, and Guatemala). The tree has been introduced into Ceylon.

History.—The drug derives its name from the fact that when first imported into Spain it came *via* Callao in Peru. It was known to Monardes and the method of preparation was described as early as 1576, although afterwards forgotten. In 1863 the collection was described and illustrated by Dorat.*

Collection and Preparation.—In November or December strips of bark, measuring about 30 × 15 cm., are beaten with the back of an axe or other blunt instrument. The bark soon cracks and may be pulled off in about a fortnight. As in the case of Tolu balsam, the secretion is purely pathological in origin and very little balsam can be obtained from the bark unless it is charred with a torch about a week after the beating. The balsam produced in the bark is obtained by boiling the bark in water and is known as "*tacuasonte*" (prepared without fire) or "*balsamo de cascara*" (balsam of the bark).

The greater part of the balsam is, however, prepared, after the removal of the bark, by beating and charring the wood

* Dorat, *Pharmaceutical Journal*, 1883, 248.

(see Fig. 161). The balsam which exudes is soaked up with rags, which, after some days, are cleaned by gently boiling with water and squeezing in a rope press.* The balsam sinks to the bottom and, the water having been decanted, the balsam (*balsamo de trapo*) is poured off and strained. The drug is chiefly exported from Acajutla (San Salvador) and Belize (British Honduras) in tin canisters holding about 27 kilos.

Characters.—Balsam of Peru is a viscid liquid of a somewhat oily nature, but free from stickiness and stringiness. When seen in bulk it is dark brown or nearly black in colour, but in thin layers it is reddish-brown and transparent. The original



FIG. 161.—The collection of balsam of Peru, after Dorat (1863)
(*Pharmaceutical Journal*).

containers have a whitish scum on the surface. The balsam has a pleasant, somewhat vanilla-like odour and an acrid, slightly bitter taste.

The drug is almost insoluble in water. It is soluble in one volume of alcohol (90 per cent.), but the solution becomes turbid on the addition of further solvent. The specific gravity, 1.140 to 1.170, is a good indication of purity. Tests for absence of fatty oils, benzaldehyde, and turpentine are described in the Pharmacopœia.

* For modern illustrations of the collection of balsam of Peru, see Tschirch's *Handbuch der Pharmakognosie*, 2nd edition. It will be observed that a rope press of the type illustrated by Dorat is still used.

PHARMACOGNOSY

Constituents.—The official drug is required to contain not less than 53 per cent. of balsamic esters, which have a saponification value of not less than 235. The chief balsamic esters present are benzyl cinnamate (cinnamein), $C_6H_5.CH : CH.CO.O.CH_2.C_6H_5$ (sap. value 234), benzyl benzoate (sap. value 264.3), and cinnamyl cinnamate (styracin). The drug usually contains from 56 to 66 per cent. of these esters. It also contains about 28 per cent. of resin, which is said to consist of peruresinotannol combined with cinnamic and benzoic acids, an alcohol (nerolidol or peruvial), and small quantities of vanillin and free cinnamic acid.

Uses.—Balsam of Peru is used as an antiseptic dressing for wounds and as a parasiticide.

TRAGACANTHÆ GUMMI

Tragacantha, B.P. ; *Tragacanth* ; F. *Gomme Adragante* ;
G. *Tragant*

Sources.—Tragacanth is a gum which is obtained by incision from the stems of various species of *Astragalus*. The chief gum-yielding species are thorny shrubs found in the mountainous districts of Asia Minor, Syria, Armenia, Kurdistan, Iraq, Iran and the U.S.S.R.* Persian tragacanth, which is the variety specified in the British Pharmacopœia is the kind chiefly used in this country. The Smyrna or Anatolian tragacanth from Asia Minor is, however, much used on the Continent.

The term Persian tragacanth is used by pharmacists to denote the better grades of tragacanth produced in Iran (Persia), Turkish Kurdistan, and Iraq. The chief producing districts of Persian tragacanth † and the centres to which the gum is sent are shown in the following table and accompanying map :—

* In a recent letter to the author the U.S.S.R. Institute of Plant Industry state, "Tragacanth is obtained in Turkmenistan, in districts bordering on Iran, from *Astragalus karakalensis* Fr. and Sint., *A. piletocladus* Fr. and Sint., and probably from other species. A second region of tragacanth production in the U.S.S.R. is Transcaucasia, particularly Azerbaidzhan (Talysh district), and, to a lesser extent, Armenia. In this region the chief plants yielding this gum are : *Astragalus erinaceus* Fisch. and *A. aureus* Willd. Other species sharing to a less extent in tragacanth production in this region are *A. microcephalus* Willd., *A. Arnacantha* MB., *A. persicus* F. abd Mey., *A. Meyeri* Boiss., and a few others."

† Much of the following information is abstracted from an article by the author, *P.J.* 1936, Aug., 206-208.

DISTRICT	ROUTE VIA
Non-Persian Kurdistan ..	Sulaimanieh and Baghdad
Persian Kurdistan, Hamadan, and Kermanshah ..	Qasr-i-Shirin and Baghdad
Isfahan and N.E. Districts ..	Mohammerah and/or Baghdad
Quantities drawn by the U.S.S.R.	The Caspian Sea
Province of Fars ..	Shiraz and Bushire
Kerman District ..	Bundar-Abbas

The following table shows the approximate geographical distribution of *Astragalus gummifer* and of other gum-yielding species found in the districts in which Persian tragacanth is collected :—

SPECIES	GEOGRAPHICAL DISTRIBUTION
<i>A. gummifer</i>	Northern Kurdistan, Armenia, Asia Minor and Syria
<i>A. kurdicus</i>	Southern Kurdistan to Asia Minor and Syria
<i>A. brachycalyx</i>	Iranian Kurdistan and Luristan
<i>A. eriostylus</i>	Luristan
<i>A. pycnocladus</i>	Kermanshah (Shahu and Avroman Mts.)
<i>A. verus</i>	Western Iran
<i>A. leiocladus</i>	Western and Central Iran
<i>A. adscendens</i>	South-Western and Southern Iran
<i>A. strobiliferus</i>	Eastern Iran
<i>A. heratensis</i>	Khorasan to Afghanistan



FIG. 162.—Sources of Persian tragacanth (*Pharmaceutical Journal*).

History.—Tragacanth was well known to Theophrastus and Dioscorides. It was imported into Italy during the Middle Ages.

Formation.—The mode of formation of tragacanth is entirely different from that of acacia, the gum exuding immediately after injury and therefore being preformed in the plant while acacia is slowly produced after injury. A section of a tragacanth stem (Fig. 163) shows that the cell walls of

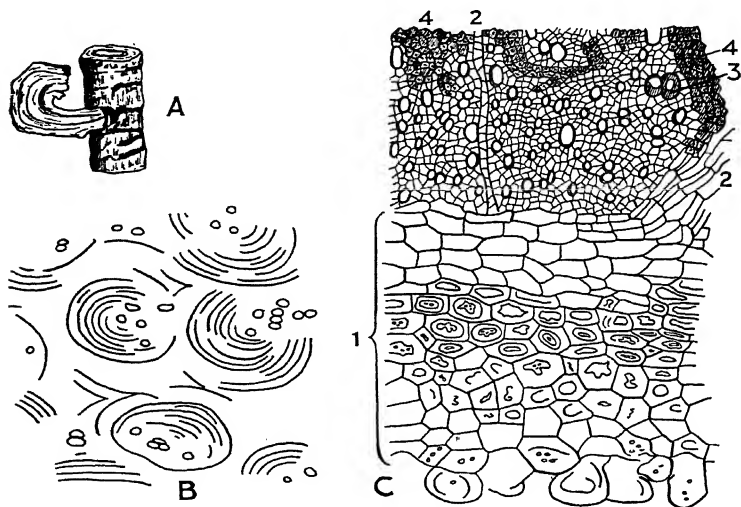


FIG. 163.—A, tragacanth exuding from a cut branch; B, section of Smyrna tragacanth showing the stratification of the mucilage cells and the small starch grains; C, a transverse section through the pith and the inner part of the wood of *Astragalus gummifer*. 1, the pith showing gummosis; 2, medullary rays; 3, vessels containing gum; 4, wood fibres. (A after Planchon, B after Flückiger, C after Tschirch.)

the pith and medullary rays are gradually transformed into gum, the change being termed “gummosis.” The gum absorbs water and a considerable pressure is set up within the stem. Hanbury, having cut off branches of a living plant, states, “there immediately exudes from the centre a stream of soft, solid tragacanth, pushing itself out like a worm, to the length of three-quarters of an inch, sometimes in the course of half an hour.”

Collection.—Most of the plants from which tragacanth is collected grow at an altitude of 4,000 to 10,000 feet. The shrubs are very thorny, since each of their compound leaves has a stout, sharply pointed rachis which persists after the fall of the leaflets. The mode of collection varies somewhat in different districts, but the following details of collection in the province of Fars is typical:—

Gum can be obtained from the plants in their first year, but is then said to be of poor quality and unfit for commercial use. The plants are therefore tapped in the second year. The earth is taken away from the base to a depth of two inches,



FIG. 164.—Tragacanth exuding from cuts (*Pharmaceutical Journal*).

and the exposed part incised with a sharp knife having a thin cutting edge (Fig. 165, A). A wedge-shaped piece of wood (Fig. 165, B) is used by the collector to force open the incision so that the gum will exude more freely. The wedge is generally left in the cut for some twelve to twenty-four hours before being withdrawn. The gum exudes as shown in Fig. 164, and is collected two days after the incision. Some of the plants are burned at the top after having had the incision made. The plant then sickens and gives off a greater quantity of gum. This practice is, however, not universal, as many plants cannot recover their strength and are killed by the burning. The gum obtained after burning is of lower quality than that obtained by incision only, being reddish and dirty looking.

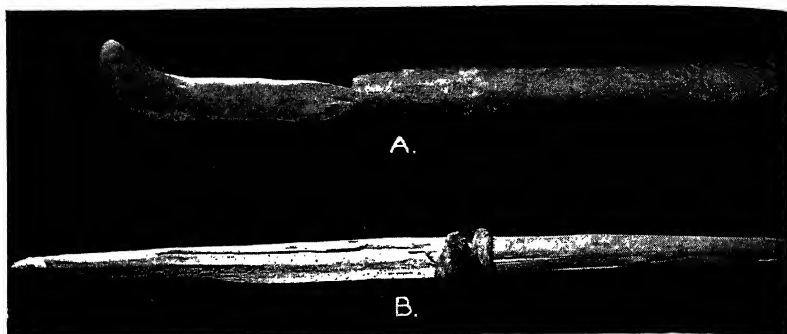


FIG. 165.—Instruments used for the collection of tragacanth (*Pharmaceutical Journal*).



166.—Grades of tragacanth (*Pharmaceutical Journal*).

The gum is collected by the villagers and is brought to the nearest centre by pack animals.

Grades.—Tragacanth is graded in Iran or 'Iraq into seven qualities by the exporter or middleman. The best grades form the official drug, whilst the middle and lower grades are used in the textile and other industries. The commercial description and approximate relative values of these grades are as follows :—

Grade	Description	Relative Value
No. 1	Fine flat druggists' ribbon	100
No. 2	No. 2 druggists' ribbon	67
No. 3	Flat ribbon (textile and drug)	44
No. 4	Flat amber thin leaf (textile)	37
No. 5	Flat amber thick leaf (textile)	22
No. 6	Thick brown leaf (textile)	15
No. 7	Mixed hoggy pickings	9

On arrival in London the drug is "worked" as follows. In a consignment of, say, fifty cases of No. 1 grade some cases will contain a somewhat finer quality of gum than others, whilst the contents of some may have deteriorated in transit. The cases are therefore opened, inspected, and those of similar quality "bulked" (Fig. 167), mixed and repacked. In this way the original consignment may be worked into several lots and buyers will know that the gum in each lot is of uniform quality.

Characters.—The official Persian tragacanth occurs in flattened flakes up to 25 mm. long and 12 mm. wide. The surface shows a number of ridges, which indicate the successive, temporary stoppages of flow from the incision. The fine furrows parallel to the margin of the flake are produced by the uneven edges of the incision. The gum is white or very pale yellowish-white in colour, translucent and horny. It breaks with a short fracture, is odourless, and has little taste.

Tragacanth swells into a gelatinous mass when placed in water, but only a small portion dissolves. On the addition of a dilute solution of iodine to a fragment previously soaked in water, relatively few blue points are visible (distinction from Smyrna tragacanth, which contains more starch).

For microscopical characters, see p. 103, and Fig. 163.

Constituents.—Tragacanth consists of a water-soluble gum, tragacanthin (about 30 to 40 per cent.), and a gum which swells in water but does not dissolve and is known as bassorin (60 to 70 per cent.).

Tragacanthin was regarded by O'Sullivan (1901) as a mixture of polyarabinan-trigalactan-geddic acids, but Norman* has recently shown that it is formed from arabinose and uronic acid units. Bassorin is more complex than tragacanthin but seems to be similarly constituted.

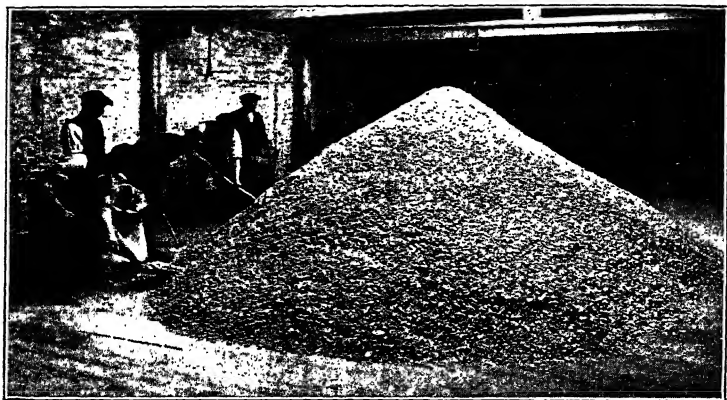


FIG. 167.—Tragacanth in bulk (*Chemist and Druggist*).

Allied Drugs.—*Non-Pharmaceutical Grades of Tragacanth.*—Large quantities of tragacanth of the grades 4 to 7 illustrated in Fig. 166 are imported and used in the textile industry and pickle manufacture. The pieces vary in shape, and are from a yellow ivory colour to almost black. The lower grades are much contaminated with earth, and their ashes give a strong reaction for iron. Of the specimens illustrated we found that numbers 1 to 6 were well within the British Pharmacopœia ash limit of 4 per cent. No. 7, on the other hand, gave 16.4 per cent. of ash and 11.8 per cent. of acid-insoluble ash. The viscosity of mucilages prepared from these grades of tragacanth falls rapidly from the No. 1 to No. 7, the marked difference in

* Norman, *Biochem. J.*, 1931, 25, 200.

price being fully justified. The lower grades of tragacanth are known as *hog gum* or *hog tragacanth*.*

Karaya Gum, *Sterculia Gum* or *Indian Tragacanth*† is obtained from *Sterculia urens* (Sterculiaceæ). Good qualities are in irregular, almost colourless, translucent, striated masses weighing up to 25 G. or more. Medium grades have a marked pinkish tinge, whilst the lower grades are very dark and contain a considerable amount of bark. Karaya gum has a marked odour of acetic acid, and when hydrolysed with 5 per cent. phosphoric acid has a volatile acidity of about 18 per cent. (tragacanth about 2 to 3 per cent.). When boiled with solution of potash it becomes slightly brownish (tragacanth canary yellow). Karaya also differs from tragacanth in that it contains no starch and stains pink with solution of Ruthenium Red.

Insoluble Shiraz Gum is a gum of doubtful botanical origin imported from Iran. When of good quality it resembles a mixture of bleached and natural Kordofan acacia. It may be distinguished from tragacanth by the fact that it contains no starch and that it gives a reaction for oxidase enzyme when treated with benzidine solution and hydrogen peroxide.

Vermicelli tragacanth was formerly obtained from *Astragalus cylleneus*, a species found in Greece. It is no longer a commercial article.

Uses.—Tragacanth is used in pharmacy as a suspending agent for insoluble powders, etc., or as a binding agent in pills and tablets. Very large quantities are used in calico printing, confectionery, etc.

ACACIÆ GUMMI

Acacia, B.P.; *Acacia Gum*, *Gum Arabic*; F. *Gomme Arabique*; G. *Arabisches Gummi*

Source.—Acacia is a dried gum obtained from the stem and branches of *A. senegal* Willd. and of some other species of *Acacia*. *A. senegal* is a tree about 6 metres high, which is abundant in the Sudan, particularly in the province of Kordofan, in Central Africa, and in West Africa (Senegambia). The

* At one time gums of this type were known as Caramania gum, Moussul gum or false tragacanth, and were whitened with white lead for admixture in Turkey with the gum exported from Smyrna and Constantinople. Although this is still referred to in text-books and the B.P.C., we have found no original reference to it since that of Maltass, *P. J.* 1855, 18.

† The name "Indian tragacanth" is also applied to the gum derived from *Cochlospermum gossypium*. According to Youngken's *Text-book of Pharmacognosy*, over two million pounds are annually imported into the U.S.A. It contains starch and a few rosette aggregates of calcium oxalate.

tree is known in Kordofan as *Hashab* and in Senegambia as *Verek*. The best gum is that produced in Kordofan from cultivated trees, but some of the Senegal gum is of good quality.

History.—Gum was brought from the Gulf of Aden to Egypt in the seventeenth century B.C., and in the works of Theophrastus it is spoken of as a product of Upper Egypt. The West African product was imported by the Portuguese in the fifteenth century.

Collection and Preparation.—Some gum exudes from wild trees as a result of the cracking of the bark, but the most esteemed, Kordofan, variety is obtained from cultivated trees. These are tapped in February and March, when they are about six years old. The tapper, with a blow from a small axe, makes a transverse incision in the trunk and so twists the axe that the bark is loosened, strips of it being then pulled off above and below the cut. The portion of trunk so bared to the cambium measures about 2 to 3 feet in length and 2 to 3 inches in breadth. This cambium produces new phloem and in about twenty to thirty days the tears of gum which have formed on the surface may be picked off.* The gum is collected in leather bags by the natives (Fig. 168), and is conveyed to El Obeid in sacks. Here the gum is garbled to free it from sand and vegetable debris, and is sorted. Not only is the gum of wild trees darker than that obtained from cultivated ones, but all the tears obtained from the same tree are not of equal quality. Other acacia gums such as talka gum, the product obtained from *A. Seyal* (the talka of the Arabs), are also separated. Some, but not all, of the gum is "ripened" by exposure to the sun, when it is bleached and dried, developing numerous cracks.

From El Obeid the drug is sent by rail to Port Sudan, whence large quantities are shipped to London. The U.S.A. now ship the greater part of their requirements direct. In the London Market Reports three grades are usually quoted, namely, bleached Kordofan, natural Kordofan, and talka. The Senegal acacia gum is largely used for pharmaceutical purposes on the Continent and is shipped to Marseilles and Bordeaux. This also occurs in three grades, namely, "gomme du bas du fleuve," "gomme du haut du fleuve," and "gomme friable."

* An acacia tree wounded for gum as described above may be seen in the Kew museum. According to Smith, *Proc. Linn. Soc. N.S. Wales*, 1904, 217, the formation of many gums is due to bacteria. Whether this is so in the case of acacia gum is a matter of doubt.

Characters.—Bleached Kordofan acacia occurs in rounded or ovoid tears up to about 3 cm. in diameter, or in angular fragments. The outer surface bears numerous fine cracks, which form during the "ripening" and make the tears opaque. The gum is white or very pale yellow in colour. The tears break readily with a somewhat glassy fracture.



FIG. 168.—Native collecting acacia gum. (Reproduced from *Gum Arabic*, by courtesy of Capt. H. S. Blunt, Clarendon Press, Oxford.)

They are odourless and have a bland and mucilaginous taste. For microscopical characters, see p. 97.

Natural Kordofan gum differs from the above in having fewer cracks, which causes it to be more transparent, and in being more yellowish or pinkish in colour. The tears are usually of less uniform size, some being quite small while

others have a diameter of 4 cm. or more. The better qualities of Senegal gum closely resemble the natural Kordofan, but some of the tears are vermiform in shape and, speaking generally, the gum is rather more yellowish in colour.

Tests.—Acacia is almost completely soluble in an equal weight of water, solution taking place rather slowly. The solution is slightly acid and becomes more so on keeping, especially if hot water is used to make the solution. It is viscid, but not glairy, and when diluted does not deposit on standing. It is lævorotatory.

A 10 per cent. aqueous solution gives no precipitate with a 20 per cent. solution of neutral lead acetate (solutions made with tragacanth, agar, Irish moss, or quince seeds all give precipitates) ; gives no colour with solution of iodine (absence of starch and dextrin) ; and, if of Pharmacopœial quality, gives no reaction for tannin with ferric chloride. The mucilage gives a blue colour when treated with solution of benzidine and a few drops of hydrogen peroxide indicating the presence of an oxydase (distinction from tragacanth).

Constituents.—According to O'Sullivan acacia gum consists of diarabanan-tetragalactan-*isogeddic* acid combined with potassium, magnesium, and calcium, each molecule yielding on hydrolysis two molecules of arabinose, four molecules of galactose and *isogeddic* acid (arabic acid). More recent work * has resulted in the isolation of a crystalline acid, which is found to be a glucuronogalactose, while the sugars formed on hydrolysis are arabinose, galactose, and rhamnose.

Acacia also contains an oxydase and about 14 per cent. water. It yields about 2.7 to 4 per cent. of ash.

Allied Drugs.—*Talka gum* is usually much broken and of variable composition, some of the tears being almost less and others brown.

Ghatti or Indian gum, which was official in the 1914 copœia, is derived from *Anogeissus latifolia* (Fam. *betaceæ*). It resembles talka in possessing tears of colours. Some of the tears are vermiform in shape their surface shows fewer cracks than even the natural

When of good quality it yields a mucilage which is lent for pharmaceutical purposes. A 1 per cent. solution a precipitate with a 10 per cent. solution of tannic acid (ion from acacia).

Heidelberger and Kendall, *J. Biol. Chem.*, 1929, **84**, 639 ; Challinor and Hirst, *J.C.S.*, 1931, 258.

Many other gums of the acacia type are occasionally met with in commerce, but a description of these is outside the scope of the present work.

SENNÆ FOLIUM

Sennæ Folium, B.P. ; *Senna*, *Senna Leaves* ; F. *Feuilles de Séné* ; G. *Sennesblätter*

Source.—*Senna* consists of the dried leaflets of *Cassia acutifolia* Delile, which are known in commerce as Alexandrian senna, and of *Cassia angustifolia* Vahl, which are known in commerce as Tinnevely senna. The senna plants are small shrubs, about 1 metre in height, with paripinnate compound leaves. *Cassia acutifolia* is indigenous to tropical Africa and is cultivated in the upper Nile territories (Kordofan, Sennar). *Cassia angustifolia* is indigenous to Somaliland, Arabia, Sind, and the Punjab, and is cultivated in South India (Tinnevely).

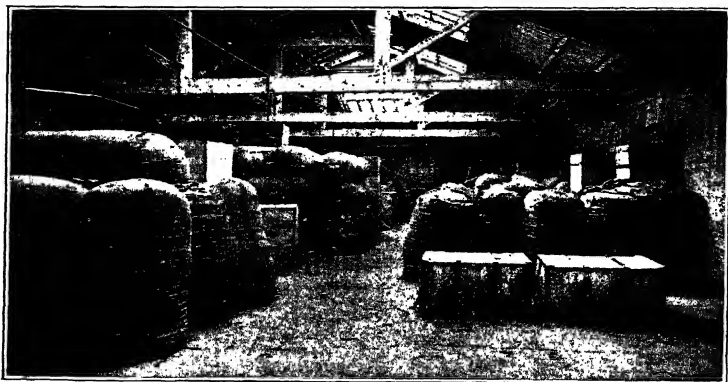


FIG. 169.—A portion of the senna stocks at South-eastern Wharf, showing bags, cases, and native-made cases (*Chemist and Druggist*).

History.—*Senna* appears to have been used since the ninth or tenth century, its introduction into medicine being due to the Arabian physicians, who used both the leaves and the pods. It was formerly exported through Alexandria, whence the name of the Sudanese drug.

Collection and Preparation.—Alexandrian senna is collected, mainly in September, from both wild and cultivated plants.

The branches bearing leaves and pods are dried in the sun and conveyed to Omdurman. Here the pods and large stalks are first separated by means of sieves (see *Senna Pods*, p. 499). That which has passed through the sieves is then "tossed" in shallow trays, the leaves working to the surface and the heavier stalk fragments and sand to the bottom. The leaves are then graded, partly by means of sieves and partly by hand picking into (i) whole leaves, (ii) whole leaves and half leaves mixed, and (iii) siftings. The whole leaves are those usually sold to the public while the other grades are

used for making galenicals. The drug is packed, somewhat loosely, in bales and sent by rail to Port Sudan, whence it is shipped to London, New York, etc.

Tinnevely senna is obtained from cultivated plants of *Cassia angustifolia* grown in South India, where the plants are more luxuriant than those found wild in Arabia. Owing to the careful way in which the drug is collected and compressed into bales, the leaflets are usually little broken. Typical bales of senna are shown in Fig. 169.

Macroscopical Characters.

—Senna leaflets bear stout petiolules. The lamina has an entire margin, acute apex, and a more or less asymmetric base. The surfaces are pubescent. Odour, slight but characteristic; taste, mucilaginous, bitterish, and unpleasant.

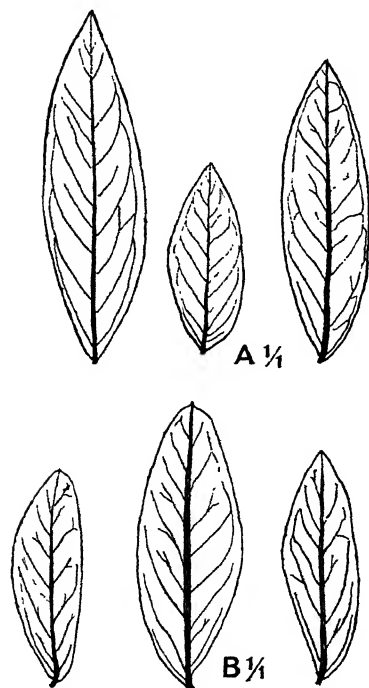


FIG. 170.—Senna leaflets. A, Indian; B, Alexandrian.

Typical senna leaflets are shown in Fig. 170. The main differences between the two varieties are as follows:—

*Alexandrian Senna.**Tinnevelly Senna.*

Macroscopic characters.	<p>Seldom exceed 40 mm. in length Greyish-green. More asymmetric at base. Rather more broken and curled at the edges. Few press markings.</p>	<p>Seldom exceed 50 mm. in length. Yellowish-green. Less asymmetric at base. Seldom broken and usually flat owing to compression. Often shows impressions due to the mid vein of other leaflets.</p>
Microscopic characters.	<p>Hairs more numerous, the average distance between each being about three epidermal cells. Most of the stomata have two subsidiary cells only. Vein-islet number 25 to 29.5.</p>	<p>Hairs less numerous, the average distance between each being about six epidermal cells. The stomata having two and three subsidiary cells respectively are in the ratio of about 7 to 3. Vein-islet number 19.5 to 22.5.</p>

Microscopical Characters.—*Senna* leaflets have an isobilateral structure (see Fig. 171). The epidermal cells have straight walls, and many contain mucilage. Both surfaces bear

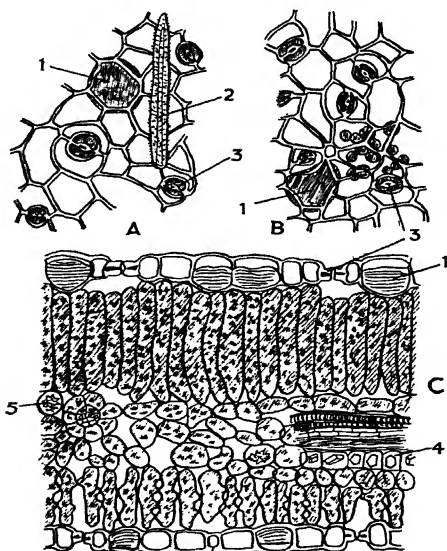


FIG. 171.—*Cassia angustifolia*. A, upper epidermis; B, lower epidermis; C, transverse section of leaflet; 1, mucilage cell; 2, hair; 3, stoma; 4, prisms of calcium oxalate; 5, rosette crystals of calcium oxalate. All ca. 200 : 1. (After Thoms, *Handbuch der Pharmazie*.)

scattered, unicellular, non-lignified warty hairs up to 260μ long. The stomata have two cells with their long axes parallel to the pore and sometimes a third or fourth subsidiary cell. The midrib and larger veins have a fibrous pericycle and a sheath of cells containing prisms of calcium oxalate about 10 to 20μ long. Cluster crystals of calcium oxalate are found in the mesophyll. For powder, see p. 105.

Senna "Stalks."—It is difficult to remove all fragments of rachis, petiole and stalk from the drug, but the amount of these structures is limited by the B.P. to not more than 1 per cent. of "stalks" and by the U.S.P. XI to not more than 8 per cent. of "stems." In the whole drug the percentage of these is determined by hand picking and weighing, but in the powdered drug the determination is made by finding the epidermal area per gram. The anatomy of senna stalks and their determination in senna powder has been worked out by Saber* (see p. 157).

Constituents.—Senna contains anthraquinone derivatives, flavonol colouring matters, a phytosterol and its glucoside, mucilage, calcium oxalate, and resin. Other constituents of importance probably remain to be isolated.

According to Maurin (1922), the Alexandrian leaves contain about 1.55 per cent. of anthraquinone derivatives and the Tinnevely about 1.35 per cent. The chief anthraquinone derivatives are aloë-emodin, $C_{14}H_5O_2(OH)_2 \cdot CH_2OH$, and rhein. Both exist in the drug in the free state and as glycosides. They were isolated by Tutin in 1913.

The colouring matters, which are yellow, are kæmpferol (1:3:4'-trihydroxyflavone), its glucoside (kæmpferin), and isorhamnetin. These substances have no laxative action.

Allied Drugs.—*Bombay, Mecca, and Arabian Sennas* are obtained from wild plants of *Cassia angustifolia* grown in Arabia. Some of the leaflets are shipped to Port Sudan and are graded like the Alexandrian drug, while some are sent to Bombay and frequently arrive in England with shipments of the Tinnevely.

The leaflets resemble those of Tinnevely senna but are somewhat more elongated and narrower, and of a brownish or brownish-green colour. Levin (1929) states that they may be distinguished microscopically from other sennas by their vein islet number. They appear to resemble closely the official leaves in activity.

* Saber, Y.B. *Pharm.*, 1934, 422 and 435.

Dog Senna, a variety formerly much esteemed, is derived from *Cassia obovata*. The plant is indigenous to Upper Egypt, but was cultivated in Italy in the sixteenth century. The leaves are obovate and quite different in appearance from the official leaflets. When in powder they may be distinguished by the papillose cells of the lower epidermis. Maurin found them to contain 1.10 to 1.15 per cent. of anthraquinone derivatives.

The leaflets of other species of *Cassia*, e.g. *C. montana*, *C. holosericea*, and *C. auriculata*, have also been imported, but may be distinguished from the genuine drug by the characters given above.

Substitute.—*Argel Leaves*, which are derived from *Solenostemma argel* (Fam. Asclepiadaceæ), were at one time regularly mixed in a definite proportion with Alexandrian senna. The plant occurs in the Sudan, but the leaves are now seldom seen in commerce. If used to adulterate senna powder it may be distinguished by the two- or three-celled hairs, each of which is surrounded by about five subsidiary cells.*

Uses.—Senna is a useful purgative either for habitual constipation or occasional use. It lacks the astringent after-effect of rhubarb. Owing to its somewhat griping effect it is often prescribed with carminatives.

SENNÆ FRUCTUS

Sennæ Fructus, B.P. ; *Senna Pods* ; F. *Follicules de Séné* ; G. *Sennesbälge*

Source.—Senna pods are the dried, ripe fruits of *C. acutifolia* and *C. angustifolia*, which are known in commerce as Alexandrian and Tinnevely senna pods respectively.

Collection.—The pods are collected with the leaves and dried as described above. After separation from the leaves they are hand-picked into various qualities, the finer being sold in cartons and the inferior ones used for making galenicals.

Characters.—The characteristic sizes and shapes of the two varieties are shown in Fig. 172. The Tinnevely pods are longer and narrower than the Alexandrian and the brown area of pericarp surrounding the seeds is greater. The remains of the style are distinct in the Tinnevely but not in the Alexandrian.

* The microscopical features of these leaves and of other senna adulterants are illustrated in Thoms, *Handbuch der Pharmazie*, V, 2, 1109.

After soaking in water the pods are readily opened and about six wedge-shaped seeds disclosed, each attached to the dorsal surface of the pod by a thin funicle. Under a lens the testas of the Tinnevely show a general reticulation and wavy, transverse ridges, while the Alexandrian show a general reticulation only. The pericarp of the pod bears unicellular hairs similar to those found on senna leaves.

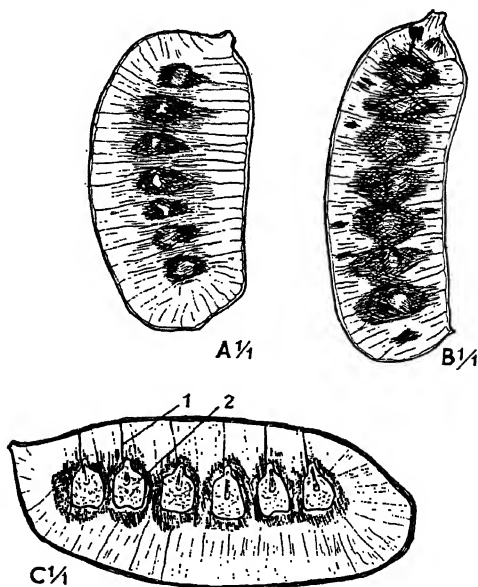


FIG. 172.—Senna pods. A, Alexandrian; B, Indian; C, Alexandrian senna pod opened to show seeds. 1, funiculus; 2, seed.

Constituents.—The constituents of the pods are similar to those of the leaves. Maurin (1922) found 1.3 per cent. of anthraquinone derivatives in the Tinnevely pods and 1.4 per cent. in the Alexandrian. The fact that the pods are less gripping than the leaves is said to be due to the fact that they contain less resin.

CASSIÆ FISTULÆ FRUCTUS

Cassia Fistula ; *Cassia Pods* ; *F. Casse en Bâtons* ;
G. Röhrenkassie

Source.—*Cassia* pods are the dried ripe fruits of *Cassia Fistula*, a large tree thought to be indigenous to India but now widely cultivated in the tropics. The drug is chiefly obtained from the West Indies (Dominica and Martinique) and Java.

Characters. — The fruit (Fig. 173) is a cylindrical, indehiscent pod about 25 to 30 cm. long and 20 to 25 mm. in diameter. It has a short, woody stalk from which run the fibrovascular bundles of the dorsal and ventral sutures. The pericarp is dark chocolate brown to black in colour, and finely striated transversely; it is thin but hard and woody. As the fruits ripen, membranous dissepiments grow between the seeds, so that each is contained in a separate chamber. Each fruit contains from 25 to 100 seeds.

The seeds are oval and reddish-brown. Each has a dark line (the raphe) on one side and is attached to the dorsal side of the fruit by a delicate funicle (cf. senna). The funicle usually breaks off close to the seed if the latter is not extracted very carefully. In the fresh pods

the seeds are completely embedded in black pulp, which, however, gradually dries on the septa. For this reason pods which do not rattle when shaken are usually preferred. A transverse section of the seed shows two, diagonally-placed,

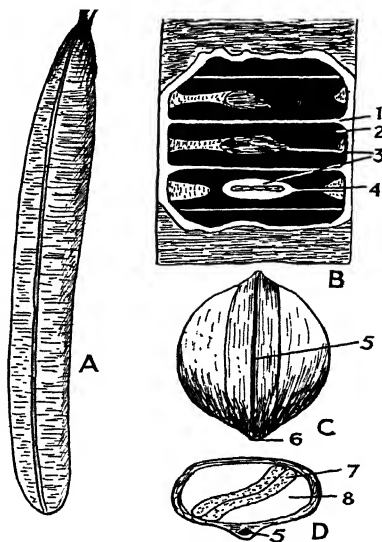


FIG. 173.—*Cassia Fistula*. A, whole fruit; B, portion of the same with pericarp partially removed; C, seed; D, transverse section of seed. 1, dissepiment; 2, pulp; 3, seed; 4, funicle; 5, raphe; 6, hilum; 7, embryo; 8, endosperm. (C and D after Thoms.)

yellow cotyledons, which are surrounded by a horny, white endosperm. The pulp has a prune-like odour, and a sweetish taste.

Constituents.—The pulp, which is official, is dissolved from the crushed fruit by percolation with water. The percolate is strained and evaporated to a soft extract.

The constituents of cassia pulp are very incompletely known. It contains about 1 per cent. of unidentified anthraquinone derivatives, 50 per cent. of sugars, gum, colouring matter, and a trace of volatile oil.

Allied Drugs.—The pods of *Cassia moschata* (Musk or Small Cassia) are smaller than those of *Cassia Fistula*, and not more than 15 mm. in diameter. The pulp is paler in colour and has a characteristic odour, which has been likened to musk and to sandalwood. The fruits are grown in Central America and are rarely seen in Europe.

Cassia grandis pods (Horse or Brazilian Cassia) are very large and laterally compressed. They are 50 to 80 cm. long and 4 to 9 cm. broad. The black pulp has a bitter, disagreeable taste. The fruits are grown in Brazil and Central America and are not used in Europe.

Uses.—Cassia pulp is an ingredient of Confection of Senna.

TAMARINDI PULPA

Tamarindus, B.P. ; West Indian, Brown, or Red Tamarinds ;
F. *Pulpe de Tamarin* ; G. *Tamarinde*

Source.—The official drug consists of the fruits of *Tamarindus indica*, which have been deprived of the brittle, outer part of the pericarp and preserved with sugar.

The tamarind tree is about 25 metres high. It is found throughout the tropics, but is indigenous to Africa. It was introduced into the West Indies by the Spaniards. The West Indian tamarinds, which are those usually used in Britain and the U.S.A., are sometimes referred to *T. indica* var. *occidentalis*. The pulp is less acid and lighter in colour than that produced in India and Africa.

Collection and Preparation.—The fruits are about 5 to 15 cm. long. They have a brittle epicarp, a pulpy mesocarp, through which runs from the stalk about five to nine, branched fibres, and a leathery endocarp. The latter forms from four to twelve chambers, in each of which is a single seed.

In the West Indies the fruits ripen in June, July, and August. The epicarps having been removed, the fruits are packed in layers in barrels, and boiling syrup is poured over them. Alternately, each layer of fruits is sprinkled with powdered sugar.

In the Old World tamarinds are usually prepared by removing the epicarps and pressing the residue into a compact mass, with or without the addition of salt.

Characters.—Tamarind pulp occurs as a reddish-brown, moist, sticky mass, in which the yellowish-brown fibres mentioned above are readily seen. Odour, pleasant and fruity; taste, sweet and acid.

The seeds are found, each enclosed in a leathery endocarp to which it is attached by a short funicle. The seeds are obscurely four-sided or ovate, and about 15 mm. long. They have a rich brown testa marked with a large patch or oreole. Within the testa, which is very thick and hard, lies the embryo. The large cotyledons are interesting since they are composed very largely of hemi-cellulose, which stains blue with iodine. Microscopical examination shows that this colour is not due to starch since it is the cell wall and not the cell contents which stain blue.

Constituents.—Tamarind pulp contains free organic acids (about 10 per cent. of tartaric, citric, and malic), their salts (about 8 per cent. of potassium hydrogen tartrate), and invert sugar. The proportion of acids and salts is somewhat lowered by the sugar added as a preservative and the sugar content correspondingly raised. The Pharmacopœia

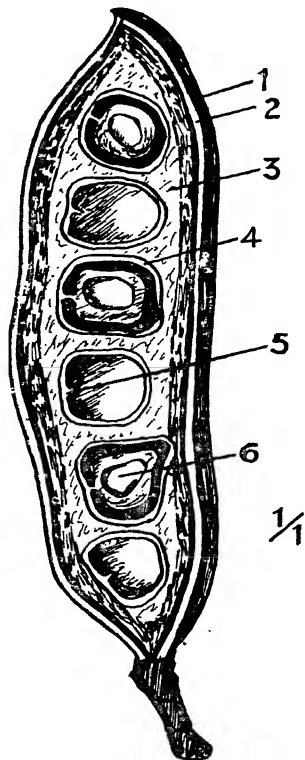


FIG. 174.—Tamarind fruit in longitudinal section. 1, epicarp; 2, fibre; 3, pulp; 4, leathery endocarp; 5, funicle; 6, oreole on seed. (After Berg and Schmidt.)

includes a test for absence of copper since this has sometimes been found in the drug, possibly owing to the use of a badly cleaned copper pan for the preparation of the syrup.

Uses.—Tamarind pulp is an ingredient of Confection of Senna.

HÆMATOXYLI LIGNUM

Lignum Campechianum ; Logwood ; F. *Bois de Campêche* ;
G. *Blauholz, Campecheholz*

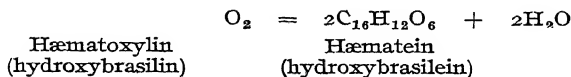
Source.—The logwood used in medicine is the unfermented heartwood of *Hæmatoxylon campechianum*. The logwood tree is about 12 to 16 metres in height. It is indigenous to Central America (Yucatan, Campeachy, British Honduras), and has been introduced into the West Indies.

Collection.—The trees are felled and the bark and colourless sapwood removed. The heartwood is exported in logs up to about 2 metres in length and 15 cm. in diameter. The colouring powers of the wood are increased by cutting it into chips by machinery, moistening, and allowing it to ferment in heaps for a month or more. This procedure was formerly adopted to fit the wood for use in dyeing. Dyers, however, now use logwood extracts and oxidising mordants. For use in medicine the unfermented wood is preferred.

Characters.—Externally logwood is purplish-red in colour, but internally it is reddish-brown. The transverse section shows alternating darker and lighter zones. These are due to the unequal distribution of the colouring matter between the zones consisting of wood fibres and those consisting of wood parenchyma and vessels. The chips should be free from green metallic lustre, showing that they have not been fermented.

A decoction of the drug gives a blue-violet colour on the addition of solution of calcium hydroxide (sappan under similar conditions gives a carmine colour).

Constituents.—Logwood contains about 10 per cent. of a sparingly soluble, colourless substance called hæmatoxylin, which readily oxidises on exposure to air to form a violet compound, hæmatein.



The medicinal wood contains hæmatoxylin, a little hæmatein, a gallitannin, and a trace of volatile oil.

Uses.—Logwood is used in medicine as an astringent. Aqueous extracts are used in dyeing and in the manufacture of inks.

Allied Drugs.—Sappan Wood is the heartwood of *Cæsalpinia Sappan* (Subfamily Cæsalpinioidæ), a tree found in India and Malaya. It contains a yellowish compound, brasilin, which is readily oxidised to the deep red brasilein. These compounds are very closely related to hæmatoxylin and hæmatein. Brasilin is also found in Brazil wood (*Cæsalpinia brasiliense*), and peachwood (*Cæsalpinia echinata*).

Red Sanders Wood is the heartwood of *Pterocarpus santalinus* (Subfamily Papilionaceæ), a tree grown in South India and the Philippine Islands. The wood occurs in very irregular billets or in small raspings. It has a dark purplish-red colour. The colouring matters differ from those of logwood and sappan in not being extracted by water. They are, however, extracted by alkaline solutions, alcohol, or ether. The chief colouring matters present are santalin, which has been obtained in blood-red crystals, and desoxysantalin.

KRAMERIÆ RADIX

Krameria, B.P., *Ratanhæ Radix* ; *Krameria* or *Rhatany* Root ;
F. *Racine de Ratanhia* ; G. *Ratanhiawurzel*

Source.—*Krameria* is the dried root of *Krameria triandra*, a small shrub with decumbent branches about 1 metre long. The drug is collected in Bolivia and Peru and is known in commerce as Peruvian rhatany.

The roots of several other species of *Krameria* are imported from time to time, but the Peruvian drug is the only one now available in commercial quantities. Para rhatany, which was derived from the Brazilian species, *Krameria argentea*, was formerly official.

History.—The plant was discovered in 1779 by Ruiz, who observed that the Peruvians used the roots for cleaning their teeth. It was introduced into Spain in 1796.

Macroscopical Characters.—The root has a knotty crown several centimetres in diameter and gives off numerous branch roots some of which attain a length of 60 cm. The official drug consists of pieces "not more than 15 mm. thick" ; larger

pieces are deficient in tannin. The roots are nearly cylindrical and are covered with a reddish-brown cork, which is scaly except in very young roots.,

A transverse section shows a reddish-brown bark which occupies about one-third of the radius and encloses a yellowish, finely-radiate wood. The bark readily separates from the wood. The former is astringent but the latter almost tasteless.

Microscopical Characters.—The cork is about 1 to 1.5 mm. thick and consists of polygonal cells with dark brown, somewhat wavy walls. The phloem contains numerous groups of non-lignified fibres and parenchyma containing starch or calcium oxalate, the latter in the form of prisms and as crystal sand. In the wood are wood fibres, pitted vessels, and medullary rays usually one cell wide.

Constituents.—*Krameria* contains about 10 per cent of a phlobatannin (*krameria*-tannic acid), a phlobaphene (*krameria* red), starch and calcium oxalate. It yields about 5 per cent. of ash and about 23 per cent. of matter soluble in dehydrated alcohol.

Uses.—*Krameria* is used as an astringent.

Allied Drug.—*Para rhatany* is distinguished from the Peruvian drug by the presence of deep transverse cracks in the bark and by the larger proportion of bark, which occupies about half the radius. It contains less alcohol-soluble matter.

COPAIBA

Copaiba, B.P.; Balsam of Copaiba or Copaiva; F. Baume de Copahu; G. Copaivabalsam

Source.—Copaiba is an oleo-resin obtained by incision from the trunks of various species of *Copaifera*, large trees indigenous to South America. The drug is largely obtained from the following species:—*C. Jacquinii*, found in Panama, Colombia, Venezuela and Guiana; *C. guianensis*, found in Guiana and Northern Brazil; and *C. reticulata*, *C. Langsdorfii*, *C. multijuga* and *C. officinalis*, found in Brazil.*

Considerable differences are to be expected in the commercial drug, since it is collected from many different species of tree, and the secretions are usually blended to meet the

* Friese, *Perfum. Essent. Oil Rec.*, 1934, 25, 218, states that 70 per cent. of Brazilian copaiba is derived from *C. reticulata* and about 10 per cent. from *C. guianensis*.

specifications of different pharmacopœias. Copaibas are therefore named according to the district in which they are collected or the port from which they are shipped, *e.g.* Maracaibo, Angostura, Para, etc.

History.—Copaiba was mentioned by a Portuguese friar in the sixteenth century. It was included in the London Pharmacopœia of 1677.

Collection and Preparation.—The oleo-resin is contained in schizogenous ducts in the wood and pith. These form a network in each zone of secondary wood, anastomoses between neighbouring zones occurring at the nodes. It also appears

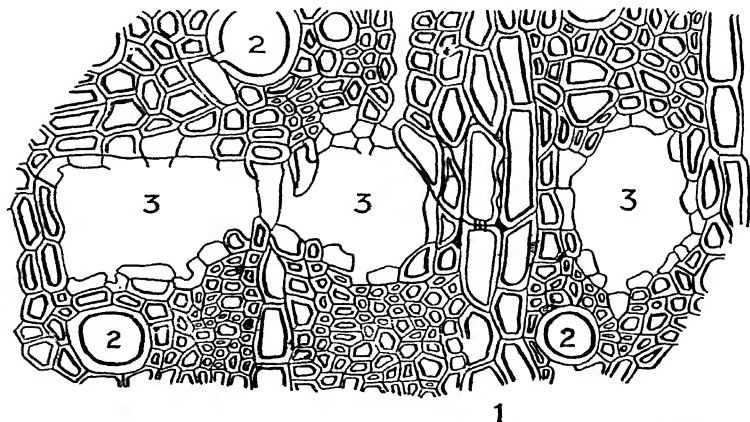


FIG. 175.—Transverse section of the wood of *Copaifera Langsdorffii*. 1, medullary ray; 2, vessel; 3, secretory cavity. (After Tschirch.)

probable, at any rate in old trees, that lysigenous cavities are produced, although some disagreement exists on this point.

The type of incision cut in the trunk of the tree closely resembles the "box" cut in pines for the collection of turpentine.* The box is cut to the centre of the tree but it is so sloped that instead of the secretion being baled out it is directed by a gutter of bark directly into the collecting vessel.

The Maracaibo or Venezuelan drug is exported in canisters each holding about 25 kilos, while the Maranhão and Para varieties arrive in small barrels holding about 40 kilos.

* For a photograph showing a box being cut, see Tschirch's *Handbuch der Pharmakognosie*, III, 2, 1150.

Characters.—Copaiba is a clear, viscous, yellow or yellowish-brown liquid. The Maracaibo is somewhat more viscous than the Para and has a distinct fluorescence.* Copaiba has a characteristic odour and an acrid, somewhat bitterish taste.

The drug is soluble in an equal volume of alcohol, but the addition of further solvent produces a precipitate. The official product has a specific gravity of 0.960 to 0.995, and when all the volatile oil has been removed leaves from 50 to 65 per cent. of residue.

Constituents.—The characters of some of the commercial varieties of copaiba are shown in the following table :—

Variety.	Specific Gravity.	Resin, per cent.	Volatile Oil, per cent.
Maracaibo	0.983 to 0.995	53.8 to 61.43	38.57 to 45.2
Maturin	0.983 to 1.150	55	45
Angostura	0.980 to 1.009	59.9	40.1
Bahia	0.980 to 1.031	59.8	40.2
Cartagena	0.958 to 0.988	46.2	53.8
Para	0.916 to 0.989	23.87 to 59.53	40.47 to 90
Surinam	0.942	—	78
British Guiana	0.980	47.89	52.11

The volatile oil of copaiba is lævorotatory and consists mainly of sesquiterpenes (α -caryophyllene, *l*-cadinene, and a little β -caryophyllene). The resins require further investigation, and those of different varieties are not identical. The Maracaibo resin is said to consist of copaivic acid (an isomer of abietic acid), β -metacopaivic acid, two copaibo-resenes, and a little crystalline illurinic acid.

Adulterants.—The absence of gurjun balsam, fixed oils, and oil of turpentine is shown by tests described in the Pharmacopœia.

Gurjun balsam is an oleo-resin produced in India from various Dipterocarpaceous trees, particularly *Dipterocarpus turbinatus*. The oil distilled from gurjun balsam has a rotation of about -80° , that from copaiba seldom exceeding -30° .

African copaiba, so-called, is probably derived from *Hardwickia Mannii*. An Indian species, *H. pinnata*, also yields a copaiba substitute. African copaiba yields a dextrorotatory oil ($+5^\circ$ to $+30^\circ$), and the Indian a lævorotatory one (-7° to

* Although the Para shows little or no fluorescence in daylight, it has a distinct fluorescence when examined in filtered ultra-violet light.

—9°). African copaiba has a peppery odour and may deposit crystals of illurinic acid on standing.

Uses.—Copaiba owes its medicinal action mainly to the volatile oil. It has a stimulant, antiseptic and diuretic action, and is used in chronic inflammation of the genito-urinary tract and in chronic bronchitis.

Order MYRTIFLORÆ

The order Myrtifloræ includes the families Lythraceæ, Thymelæaceæ, Punicaceæ, Combretaceæ and Myrtaceæ. The following drugs may be noted :—

Lawsonia; Syn. *Henna*.—Henna consists of the dried leaves of *Lawsonia alba* (Fam. Lythraceæ), a shrub cultivated in North Africa, India and Ceylon. The leaves (Fig. 176) are

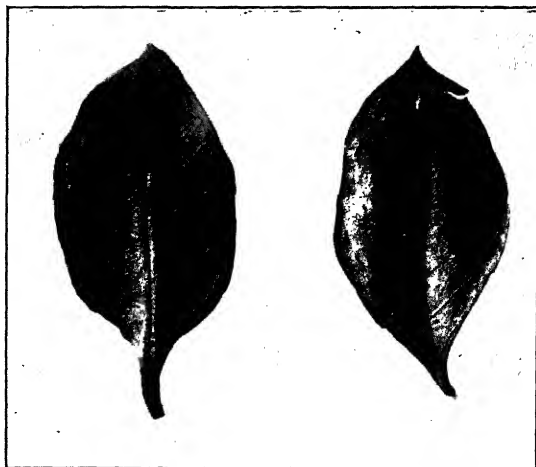


FIG. 176.—Henna leaves.

greenish-brown to brown and about 2.5 to 5 cm. long. The apex is mucronate, the margin entire and revolute, and the venation pinnate. Henna contains a colouring matter, lawson (a hydroxynaphthoquinone), fats, resin and hennatannin. Henna is commonly used as a dye for the hair, and wool washed in a dilute solution of ammonia and boiled in a decoction of the drug should be dyed a Titian-red.

Mezereum; Syn. *Mezereon Bark*.—Mezereon consists of the dried bark of *Daphne Mezereum*, *D. Laureola* and *D. Gnidium* (Fam. Thymelæaceæ). The drug occurs in long, flexible strips up to about 2 cm. wide. The outer surface is olive-brown or yellowish (*D. Mezereum*) or purplish-grey (*D. Laureola*), and marked with the scars of buds and leaves. The drugs have a persistent acrid taste, which appears to be due to a greenish-brown resin.

Myrobalanum; Syn. *Myrobalans*.—Myrobalans, as used in medicine, are the dried immature fruits of *Terminalia Chebula* (Fam. Combretaceæ), a tree common in India. The immature fruits are black, ovoid and about 1 to 3 cm. long. They contain about 20 to 40 per cent. of tannin and a greenish oleo-resin. The mature fruits, which are used as a tanning material, are larger and yellowish-brown in colour.

Gummi Indicum; Syns. *Indian Gum* or *Ghatti Gum*.—This gum is derived from *Anogeissus latifolia* (Fam. Combretaceæ) and is a substitute for acacia gum (*q.v.*).

Granati Fructus Cortex; *Pomegranate Rind*.—This consists of the dried pericarp of the fruit of *Punica Granatum* (Fam. Punicaceæ). It occurs in thin, curved pieces about 1.5 mm. thick, some of which bear the remains of the woody calyx or a scar left by the stalk. The outer surface is brownish-yellow or reddish. The inner surface bears impressions left by the seeds. The microscopy of the drug has been investigated by Griffiths.* Pomegranate rind is very astringent and contains about 28 per cent. of tannin and colouring matters. It should be carefully distinguished from the root bark which contains alkaloids.

Granati Radicis Cortex; *Pomegranate Root Bark*.—This consists of both the stem and root barks of *Punica Granatum*. It occurs in curved or channelled pieces about 5 to 10 cm. long and 1 to 3 cm. wide. The outer surface of the stem bark shows longitudinal corky furrows, a few shallow depressions and the dark apothecia of lichens, whilst that of the root bark shows depressions where the outer layers have exfoliated. The barks are smooth and yellowish on their inner surfaces and break with a short granular fracture. They contain about 0.5 to 0.9 per cent. of volatile liquid alkaloids, the chief of which are pelletierine and pseudo-pelletierine, together with about 22 per cent. of tannin.

* Griffiths, The Structure of Pomegranate Rind, *Y.B. Pharm.*, 1935, 622-630.

Family MYRTACEÆ

The Myrtaceæ includes 73 genera and about 2,750 species of evergreen shrubs and trees. The family is well represented in Australia, the East Indies, and tropical America. It is conveniently divided into two subfamilies :

Subfamily *Myrtoideæ*.—Fruit a berry or drupe, *e.g.* *Eugenia*, *Pimenta*, and *Myrtus*.

Subfamily *Leptospermoideæ*.—Fruit dry, *e.g.* in *Eucalyptus* and *Melaleuca* it is a loculicidal capsule.

The most noteworthy anatomical features are the schizolysigenous oil glands, which are found in the young stems, leaves, flowers and fruits, and the presence of bicollateral vascular bundles.

CARYOPHYLLUM

Caryophyllum, B.P. ; Cloves ; F. *Girofle*, *Clous de Girofles* ; G. *Gewürznelken*

Source.—Cloves are the dried flower buds of *Eugenia aromatica* (Linn.) Baill., a tree 10 to 20 metres high which is indigenous to the Molucca or Clove Islands. It is now cultivated in Zanzibar and in the neighbouring island of Pemba, which together produce more than three-quarters of the world's supply of cloves. Smaller quantities are grown in Penang, Malacca, Sumatra, Amboyna, Madagascar, Seychelles, Bourbon, Mauritius, the West Indies, and Cayenne.

History.—Cloves were used in China as early as 266 B.C., and by the fourth century they were known in Europe, although very expensive. Ibn Khurdadbah (*ca.* 869) and Marco Polo both thought that the spice came from Java, but Nicolo Conti in the fifteenth century learnt that they came to Java from Banda.

The Spice Islands were occupied by the Portuguese at the beginning of the sixteenth century, but they were expelled by the Dutch in 1605. As in the case of nutmegs, the Dutch made every effort to secure a monopoly, destroying all the trees in their native islands (Tarnati, Tidor, Mortir, Makian, and Bachian) and cultivating them only in a group of small islands of which Amboyna is the largest. In 1770, however, the French succeeded in introducing clove trees into Mauritius

and cultivation was afterwards taken up in Sumatra (1803), Penang, Cayenne, Madagascar, Zanzibar (1818), Pemba, etc.

Collection and Preparation.—The flower buds are collected when their lower part turns from green to crimson. In Zanzibar and Pemba collection takes place twice yearly, between August and December. The inflorescences are collected from movable platforms, or the buds are detached by means of bamboos. The cloves are dried in the open air on mats (Fig. 22) and separated from their peduncles, the latter forming a separate article of commerce known as “clove stalks” (Fig. 177, D). If left too long on the tree the buds open and the petals fall, leaving “blown cloves”; later the fruits (Fig. 177, C) known as “mother cloves” are produced. A small proportion of these, usually at a stage intermediate between that of a clove and a fully ripe fruit, are frequently found in the drug. Cloves are imported in bales covered with matting made from strips of coconut leaves.

Macroscopical Characters.—Cloves are from 10 to 17.5 mm.

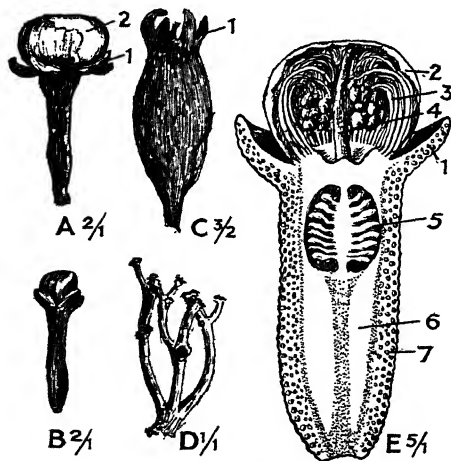


FIG. 177.—*Eugenia aromatica*. A, Penang clove; B, Zanzibar clove; C, fruit (mother clove); D, clove stalk; E, clove cut longitudinally. 1, sepal; 2, petal; 3, stamens; 4, style; 5, ovules; 6, hypanthium; 7, oil glands.

long (cf. A and B in Fig. 177). The Penang and Amboyna varieties are the largest and plumpest, and are most esteemed, but they are in such demand in the East that relatively small quantities of them reach Europe. The Zanzibar variety is, however, of good quality although smaller and leaner than the Penang and of a blackish-brown rather than a reddish-brown colour.

The “stalk” of the clove consists of a cylindrical hypanthium, or swelling of the torus, above which is a bilocular ovary containing numerous ovules attached to axile placentæ. The “head” consists of four slightly

attached to axile placentæ. The “head” consists of four slightly

projecting calyx teeth, four membranous, imbricated petals, and numerous incurved stamens surrounding a large style (Fig. 177, E).

Cloves have a strong, fragrant and spicy odour and a pungent, aromatic taste. When indented with the fingernail they readily exude oil. Cloves sink when placed in freshly boiled and cooled water* (distinction from cloves which have been exhausted of volatile oil).

Microscopical Characters.—Alongitudinal section shows under the microscope numerous schizolysigenous oil glands, which are particularly abundant in the outer part of the “stalk,” the calyx teeth, and petals. Abundant parenchyma, containing cluster crystals of calcium oxalate 6 to 20 μ in diameter, and fibrovascular bundles will also be noted. The anthers have a characteristic fibrous layer and contain pollen grains 15 to 20 μ in diameter which are triangular in outline.

A transverse section of the hypanthium (Fig. 178) shows a very heavily cuticularised epidermis in which are occasional stomata. Below this is a zone rich in oil glands, followed by a ring of fibrovascular bundles, a parenchymatous zone exhibiting large air spaces,

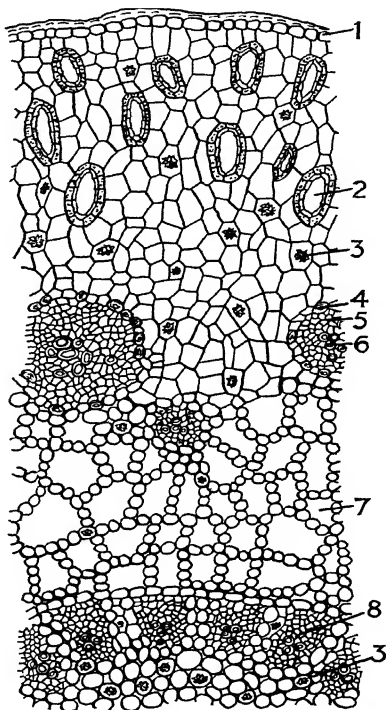


FIG. 178.—Transverse section of clove. 1, epidermis; 2, oil gland; 3, rosette of calcium oxalate; 4, phloem fibre; 5, phloem; 6, xylem; 7, air space; 8, fibro-vascular bundle with internal phloem. (After Hérail.)

* Genuine cloves will sometimes float when placed in water owing to the air bubbles on their surface. If, however, the water is first boiled and cooled these bubbles rapidly dissolve and the cloves sink. The quality of cloves is sometimes judged by setting one on fire and observing how it burns.

and a ring of bicollateral vascular bundles. If a section is mounted in a concentrated solution of potassium hydroxide, acicular and radiately aggregate crystals separate in the oil glands owing to the presence of the phenol, eugenol, in the oil.

For details of the powder, see p. 99.

Starch, prisms of calcium oxalate, and sclerenchymatous cells are absent from a powder consisting of the flower buds only. The Pharmacopœia, however, admits a drug containing not more than 5 per cent. of clove stalks and not more than 1 per cent. of other organic matter (clove fruits, etc.). Clove stalks contain bast fibres and sclerenchymatous cells in the ratio of 10 to 21,* while clove fruits contain starch.

Constituents.—Cloves contain about 14 to 21 per cent. of volatile oil (see below), 10 to 13 per cent. of tannin, and a crystalline substance called caryophyllin. The latter is white and odourless, and is soluble in ether and boiling alcohol. Cloves yield about 6.5 per cent. of ash (official limit not more than 10 per cent.).

Clove stalks yield 5 to 6 per cent. of volatile oil.

Uses.—Cloves are used as a stimulant aromatic and for the preparation of the volatile oil.

OLEUM CARYOPHYLLI

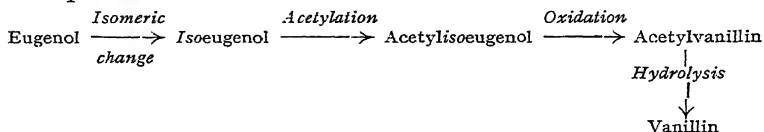
Oleum Caryophylli, B.P. ; Oil of Cloves ; F. Huile Volatile de Girofle ; G. Nelkenöl

Oil of cloves is prepared by steam distillation. It is a colourless or pale yellow liquid, which is slightly heavier than water (sp. gr. 1.047 to 1.060). It is soluble in from one to two volumes of alcohol (70 per cent.).

Clove oil contains 84 to 95 per cent. of phenols (eugenol with about 3 per cent. of acetyleugenol), sesquiterpenes (α - and β -caryophyllenes), and small quantities of esters, ketones, and alcohols. The official oil has a phenol content of 85 to 90 per cent. The phenols are estimated by absorption with solution of potassium hydroxide in a graduated flask as described in the Pharmacopœia. Those oils which have a

* The proportion of clove stalks present in a particular sample of powdered cloves may be accurately determined by making counts of the relative number of bast fibres and sclerenchymatous cells. For example, a sample containing bast fibres and sclerenchymatous cells in the ratio of 6 to 12 contains 60 per cent. of clove stalks. A full account of the method will be found in Schneider's *Microanalysis of Powdered Vegetable Drugs*, pp. 154-162.

relatively low phenol content are known in commerce as "opt," and are the ones mainly used in pharmacy, while the "strong" oils are used in the manufacture of vanillin. The stages leading to the conversion of eugenol into vanillin may be represented :



Oil of cloves is used as a flavouring agent, stimulant aromatic, and antiseptic.

PIMENTÆ FRUCTUS

Pimento ; *Allspice*, *Jamaica* or *Clove Pepper* ; F. *Toute-épice*, *Piment de la Jamaïque* ; G. *Englisches Gewürz*, *Nelkenpfeffer*

Source.—Pimento is the dried nearly ripe fruit of *Pimenta officinalis*, an evergreen tree grown in the West Indies (Jamaica, Cuba, Trinidad, etc.) and Central America.

The fruits are collected before they are quite ripe as they otherwise lose much of their aroma and become filled with a sweet pulp.

Characters.—The pimento flower and fruit closely resemble those of the clove. The bilocular ovary, however, develops two seeds whereas only one is produced in the clove.

Pimento fruits are globular and from 4 to 7 mm. in diameter. At the apex of the fruit are four, small calyx teeth surrounding a short style (cf. clove fruit, Fig. 177, C). The pericarp is reddish-brown, rough and woody, and about 1 mm. thick. Sections show numerous oil glands in the pericarp. Each of the two loculi contains a single plano-convex seed. Pimento has a characteristic, aromatic odour and taste.

Constituents.—Pimento fruits yield about 3 to 4.5 per cent. of volatile oil which, when estimated by the method used for oil of cloves, shows a phenol content of 65 to 80 per cent. The oil also contains cineole, *l*-phellandrene, and caryophyllene.

Substitutes.—The fruits of four other species of *Pimenta* are used as spices in the West Indies, Guiana, or Venezuela. English supplies of the spice are, however, derived almost exclusively from Jamaica, where the fruits are marketed by a pimento growers' association, and adulteration is unlikely.

OLEUM EUCALYPTI

Oleum Eucalypti, B.P. ; Oil of *Eucalyptus* ; F. *Huile Volatile de Eucalyptus* ; G. *Eucalyptusöl*

Source.—Oil of eucalyptus is a volatile oil distilled from the fresh leaves of various species of *Eucalyptus*, and rectified. Eucalyptus oils are distilled in Australia and Tasmania, and to a small extent in Algiers, the South of France, Italy, etc.

The genus *Eucalyptus* is a very large one, but only a certain number of species produce oils suitable for medicinal use.

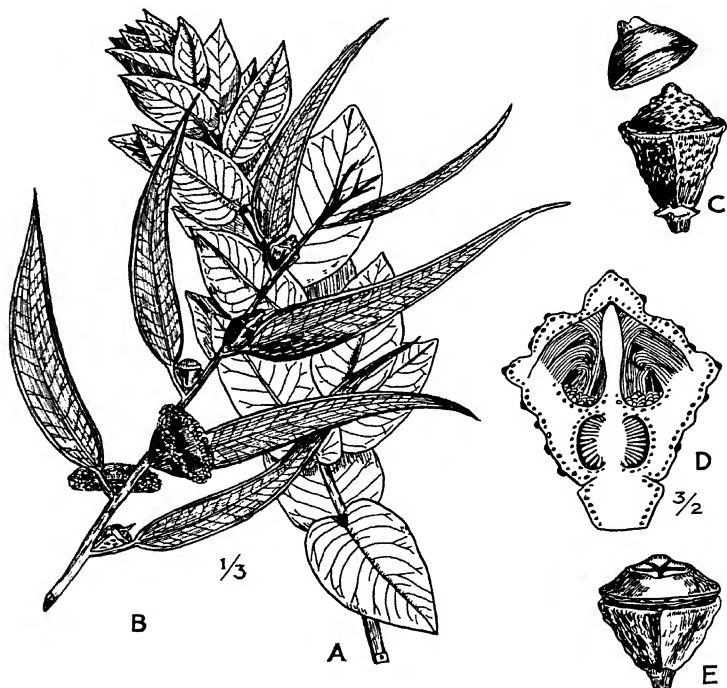


FIG. 179.—*Eucalyptus globulus*. A, branch bearing young leaves ; B, older branch with flowers ; C, bud with outer lid ; D, longitudinal section of bud with inner lid only ; E, fruit. (After Tschirch's *Handbuch der Pharmakognosie*.)

The chief requirements are a high cineole content and the absence of appreciable quantities of phellandrene and aldehydes. Suitable oils are derived from *E. polybractea*, *E. Smithii*, and *E. australiana*. In the case of the latter species, the oil used in pharmacy is that collected during the first hour of the distillation, that which passes over subsequently being used for mineral separation.

Characters of Plant.—Eucalyptus trees possess two kinds of leaves, those on young plants being cordate and sessile, while those on mature trees are petiolate and scimitar-shaped (Fig. 179, A and B). Differences, of course, exist among the various species. Both kinds of leaf contain oil glands in the mesophyll and are used for the preparation of oil.

In the flower the petals form a two-layered cap, which separates as the flower opens. The fruit is a capsule which splits loculicidally in the upper portion. Fig. 179, D, should be compared with the longitudinal section of a clove.

Characters of Oil.—Oil of eucalyptus is a colourless or pale yellow liquid. It has an aromatic and camphoraceous odour; and a pungent, camphoraceous taste, which is followed by a sensation of cold. Some of the characters of the oils referred to above are shown in the following table:—

	<i>E. australiana</i> (1st hour's distillation).	<i>E. polybractea</i>	<i>E. Smithii</i> .
Specific Gravity ..	0.9211	0.9143 to 0.9300	0.9098 to 0.9210
Optical Rotation ..	+1.4°	— 2°	+4.2° to +7.6°
Refractive Index ..	1.4628	1.4592 to 1.4736	1.4571 to 1.4650
Cineole *	74 per cent.	up to 90 per cent.	61.5 to 85.2 per cent.

Other species of *Eucalyptus* yield oils suitable for use in medicine, e.g. *Eucalyptus globulus*. The latter oil is, however, now of minor importance. Parry lists over thirty *Eucalyptus* species which yield oils containing an appreciable quantity of the terpene phellandrene for which a limit test is given in the Pharmacopœia. Other oils are excluded by the official limit test for aldehydes. One of the latter is "citron-scented"

* These figures are not strictly comparable with one another or with the official requirement, being arrived at by the phosphate or the resorcinol methods and not by the official assay process. Cineole is also known as eucalyptol and cajuputol.

eucalyptus oil, which is derived from *Eucalyptus citriodora*. It is used in perfumery and contains a high proportion of the aldehyde, citronellal.

OLEUM CAJUPUTI

Oleum Cajuputi, B.P. ; *Oil of Cajuput* ; F. *Essence de Cajeput* ; G. *Cajeputöl*

Source.—Oil of cajuput is a volatile oil distilled from the fresh leaves of *Melaleuca Leucadendron* Linn. and other species of *Melaleuca*, and rectified by steam distillation. The plants are evergreen shrubs or trees found in the East Indies and Australia. Most of the oil is produced in the islands of Bouru and Banda. It is exported in wine bottles or drums.

History.—The oil was first described by Rumphius in 1741. Its use in England dates from about 1788, when it was included in the Edinburgh Pharmacopœia.

Characters.—The unrectified oil contains sufficient copper, probably derived from the still, to give it a distinct green or bluish-green colour. Redistillation in steam gives a colourless or yellow oil. It has a pleasant, camphoraceous odour and a bitter, aromatic and camphoraceous taste.

Constituents.—Oil of cajuput contains about 50 to 60 per cent. of cineole, terpineol and its acetate, and *l*-pinene.

Uses.—The oil is used externally for rheumatism and certain skin diseases, and internally for flatulent colic, etc.

Order UMBELLIFLORÆ

The Umbellifloræ comprises the families Umbelliferæ, Araliaceæ, and Cornaceæ.

Family UMBELLIFERÆ

The Umbelliferæ includes about 270 genera and 2,700 species. Most of the members are herbs with furrowed stems and hollow internodes. Some are annuals, *e.g.* coriander, some biennials, *e.g.* hemlock, and some perennials, *e.g.* species of *Ferula*. The leaves are usually large and have a sheathing base and much divided lamina. The flowers are small and arranged in simple or compound umbels. Each has a five-

lobed calyx, five petals, five stamens which are inflexed in the bud, and an inferior two-celled ovary. The fruit is a cremocarp, which is frequently crowned with a conspicuous stigma-bearing disc known as the stylopodium. When ripe the two mericarps separate from one another but frequently remain attached to the simple or forked carpophore which lies between them. The line separating the two mericarps is known as the commissure.

Each mericarp contains a single seed which consists of a large, oily endosperm, which has a small embryo embedded in it near the apex. Five primary ridges containing fibrovascular bundles run from base to apex in the pericarp, and secondary ridges sometimes alternate with these. Between the ridges are schizogenous oleo-resin canals (vittæ).

In addition to the vittæ found in the fruit, schizogenous resin ducts occur in the stems and roots. These yield products such as asafetida, galbanum, and ammoniacum. Medullary bundles are found in the stems and roots of many species, e.g. in *Ferula* (see Fig. 185). A similar structure is found in the tuberous roots of the British plant, *Oenanthe crocata*.

Apii Fructus; *Apium*; *Celery*; *Celery Fruit*.—The drug consists of the dried ripe fruits of *Apium graveolens*. The cremocarp is brown, subspherical and about 1 to 1.5 mm. long. The mericarps are mostly separate in the drug and each shows five straight primary ridges. A transverse section is almost pentagonal and shows 6 to 9 vittæ, 2 on the commissural surface and 4 to 7 in the grooves of the dorsal surface. Odour and taste, aromatic. Celery fruits contain 2 to 3 per cent. of oil consisting of terpenes with smaller quantities of the anhydride of sedanonic acid, the lactone of sedanolic acid and phenols.

Conii Fructus; *Hemlock Fruit*.—The drug consists of the dried unripe fruits of *Conium maculatum*, the spotted hemlock, a poisonous biennial plant indigenous to Britain and Europe.

The fruit is a broadly ovate, somewhat laterally-compressed cremocarp about 3 mm. long. It bears a small stylopod and the remains of the stigmas. Each mericarp has five prominent, primary ridges, the width of which is constantly altering so as to give them a beaded appearance. The transverse section differs from that of most umbelliferous fruits in not showing conspicuous vittæ, although numerous very small ones are actually present. The endosperm is deeply grooved and is surrounded by well-marked, alkaloid-containing layers.

When hemlock is treated with solution of potassium hydroxide it develops a strong, mouse-like odour owing to liberation of the alkaloid, coniine. The latter is volatile and may be steam distilled. It is present to the extent of 1 to 2.5 per cent. together with N-methyl coniine, conhydrine, pseudo-conhydrine, and γ -coniceine.

Hemlock was the plant used by the Greeks for preparing a draught by means of which criminals were put to death. It was employed in Anglo-Saxon medicine and was in considerable use until about fifty years ago. Although now rarely employed it merits attention as one of the commonest of our indigenous poisonous plants, and on account of the fact that coniine was the first alkaloid to be synthesised (Ladenburg, 1886).

FENICULI FRUCTUS

Fœniculum, B.P.; *Fennel Fruit*; *F. Fruit de Fenouil*;
G. Fenchel

Source.—Fennel consists of the dried ripe fruits of *Fœniculum vulgare* Miller, obtained from cultivated plants. Fennel is cultivated in Germany, Holland, Austria, Hungary, Galicia, Bulgaria, Roumania, Russia, the South of France, Italy, and in North America. The German, Galician, and Russian fruits are usually considered the best for pharmaceutical purposes. The fennel is a variable plant and the following subspecies and varieties are recognised:—

Subspecies I, *piperitum* Coutinho, a wild fennel found in Sicily.

Subspecies II, *capillaceum* (Gilib.) Holmboe, a fennel which is indigenous to the Mediterranean but is widely cultivated. It exists in three varieties, namely, var. *α -vulgare*, var. *β -dulce*, and var. *γ -azoricum*. The common English fennel is a perennial herb about 1 to 1.5 metres high. The leaves are divided into hair-like segments, a character which is denoted by the name *capillaceum* for the subspecies.

History.—Fennel fruits were used by the ancient Romans. The succulent fruits were also used by them as a vegetable and are so employed in southern Italy at the present time. The cultivation of the plant in Central Europe was encouraged by Charlemagne.

Collection and Preparation.—The whole plants are cut when the fruits are ripe, dried in the sun, and the fruits separated by thrashing. Other umbelliferous fruits are prepared in the same way. It is said that some of the commercial oil of fennel is prepared by distilling the whole herb.

Macroscopical Characters.—The commercial drug consists partly of whole cremocarps (Fig. 181, A), some of which have

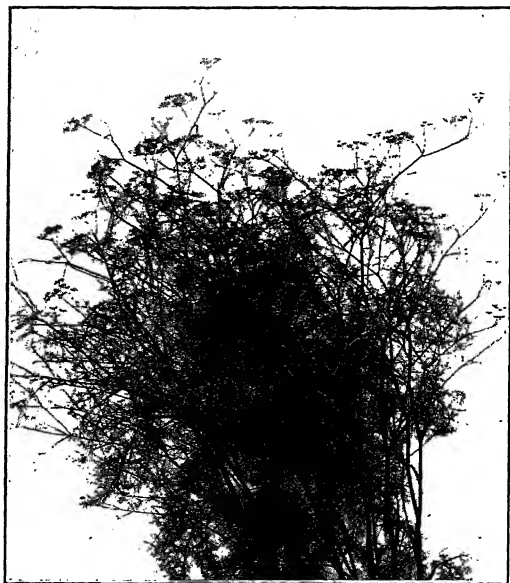


FIG. 180.—*Foeniculum vulgare*. Fruiting plant (Sutcliffe).

the pedicel attached, and partly of isolated mericarps. The fruits are glabrous and are crowned with a stylopod. The mericarps are straight or but slightly curved, from 5 to 10 mm. long and 1.5 to 4 mm. broad. Each bears five, almost equally prominent, ridges. When cut transversely, the vittæ may be seen with a lens but are best examined microscopically. Odour, aromatic; taste, strongly aromatic.

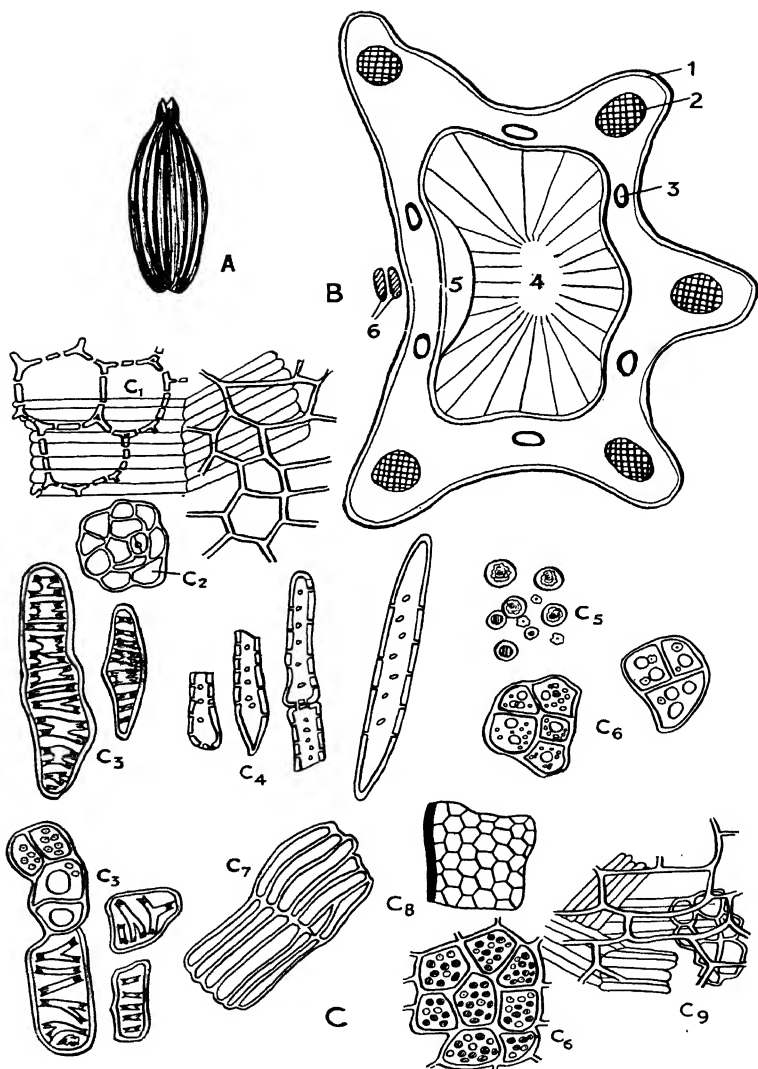


FIG. 181.—Fennel. A, whole fruit; B, transverse section of mericarp. 1, epidermis; 2, fibro-vascular bundle; 3, vitta; 4, endosperm; 5, raphe; 6, carpophore. C, powdered fennel. C₁, inner epidermis of pericarp consisting of elongated parenchymatous cells in parallel groups

Microscopical Characters.—A transverse section of a fennel mericarp (Fig. 181, B) shows five primary ridges in each of which is a vascular strand; six vittæ, four on the dorsal and two on the commissural surface, and a non-grooved endosperm. The raphe lies on the inner side of the endosperm. The small embryo, since it lies near the apex of the mericarp, will only be seen in sections passing through that region.

More detailed examination shows that the outer epidermis of the pericarp is glabrous (distinction from many other umbelliferous fruits), and that it is composed of polygonal cells having a smooth cuticle and occasional stomata (Fig. 181, C₂). The mesocarp consists of parenchyma and, very characteristic, lignified, reticulate cells (C₃). In the ridges are tracheids and fibres (C₄). The vittæ are lined with small, dark reddish-brown cells (C₅). The inner epidermis of the pericarp consists of elongated, parenchymatous cells in groups of six or more; in the powder these frequently adhere to the parenchyma of the mesocarp (C₁) or to the seed coat (C₉).

The testa is thin and consists of brownish, tangentially-elongated cells having granular contents. Within it lies a large endosperm consisting of colourless, rather thick-walled parenchyma which contains small aleurone grains (C₆ and C₅) and globules of fixed oil. Microspheroidal crystals of calcium oxalate 2 to 5 μ are present in the aleurone grains. Starch is absent. For powder, see p. 99.

Constituents.—Fennels contain about 2 to 5 per cent. of volatile oil. In German, Russian, and Galician fennels the oil content is high and the oil contains about 60 per cent. of anethole and 18 to 22 per cent. of the ketone, fenchone, C₁₀H₁₆O. The oil of sweet or Roman fennel contains little or no fenchone, Japanese contains about 10 per cent. and Indian about 6·7 per cent. Oils containing little fenchone usually have a high anethole content. Anethole, C₁₀H₁₂O, is a phenolic ether. It readily separates from the oil on cooling, particularly if a crystal of anethole be added. Its presence in the "bitter" oils of fennel gives them their distinctive taste.

Fennel also contains fixed oil, aleurone, and calcium oxalate. It yields about 9 per cent. of ash (official limit, 12 per cent.).

of six or more with adjacent parenchyma of mesocarp; C₂, outer epidermis with stoma; C₃, reticulate cells of mesocarp; C₄, tracheids and fibre; C₅, aleurone grains; C₆, fragments of endosperm; C₇, inner epidermis of pericarp; C₈, lining of a vitta; C₉, a similar fragment to C₁ but with adhering seed coat. (C after Thoms, *Handbuch der Pharmazie*.)

Varieties.—The above description applies most closely to the *German, Russian, Galician, and Roumanian* fruits. These may, however, be distinguished from one another by their sizes and by the dimensions of the vittæ as seen in transverse section.

Variety.	Size of Fruit.	Size of Vittæ in T.S.	Volatile Oil, per cent.
German	6-10 mm. × 3-4 mm.	0.2-0.22 mm. × 0.07-0.08 mm.	4.7
Russian	5-6 mm. × 1.5-4 mm.	0.2 mm. × 0.04-0.05 mm.	4.8
Galician	4-5 mm. × 1-1.5 mm.	0.2-0.22 mm. × 0.08-0.10 mm.	4.4

French Bitter Fennel is 4 to 5 mm. long and 2 to 3 mm. broad, and greenish in colour. The fruits are broader towards the apex than the German fennel,* and have a sweet, anise-like taste. The vittæ measure in transverse section 0.11 mm. in length and 0.04 to 0.05 mm. in breadth. Sweet fennel yields 2 to 3 per cent. of volatile oil, which contains little or no fenchone.

Japanese Fennel is 3 to 4 mm. long and 2 to 3 mm. broad, ovoid in shape, and greenish-brown in colour. It has a sweet and camphoraceous taste. The vittæ measure in transverse section 0.15 to 0.16 mm. in length and 0.07 to 0.08 mm. in breadth. The fruits yield about 2.7 per cent. of volatile oil, which contains about 10 per cent. of fenchone.

Indian Fennel is derived from *F. panmorium*, which is possibly a variety of *F. vulgare*. The fruits are 6 to 7 mm. long, brownish in colour, and have a sweet taste. They yield only 0.72 per cent. of volatile oil, which contains 6.7 per cent. of fenchone.

Uses.—Fennel is used as an aromatic and carminative. It is an ingredient of Compound Powder of Liquorice.

CORIANDRI FRUCTUS

Coriandrum, B.P.; Coriander Fruit; *F. Coriandre*;
G. *Koriander*

Source.—Coriander is the dried, ripe fruit of *Coriandrum sativum*, an annual about 2 feet high with white or pinkish flowers. It is indigenous to Italy, but is widely cultivated in

* Figured in Thoms, *Handbuch der Pharmazie*, V, 1402.

Central and Eastern Europe, the Mediterranean (Morocco, Malta, Egypt), and India. Thuringia, Russia, and Holland are important producers.

History.—Coriander is mentioned in the papyrus of Ebers (ca. 1550 B.C.), and in the writings of Cato and Pliny. It was well known in England before the Norman Conquest and has long been cultivated in Essex.

Macroscopical Characters.—The drug usually consists of the whole cremocarps, which when ripe are about 4 mm. in diameter and of a straw-yellow colour. Each consists of two hemispherical mericarps united by their margins. The apex bears two, divergent styles. The ten, primary ridges are wavy and inconspicuous; alternating with these are eight more prominent, straight, secondary ridges. The fruits have an aromatic odour and a spicy taste. They are somewhat liable to insect attacks.

Microscopical Characters.—A transverse section of a fully ripe fruit shows only two vittæ in each mericarp, both on the commissural surface. The changes which take place on ripening are shown in Fig. 182. The numerous vittæ present in the immature fruit on the dorsal surface of each meri-

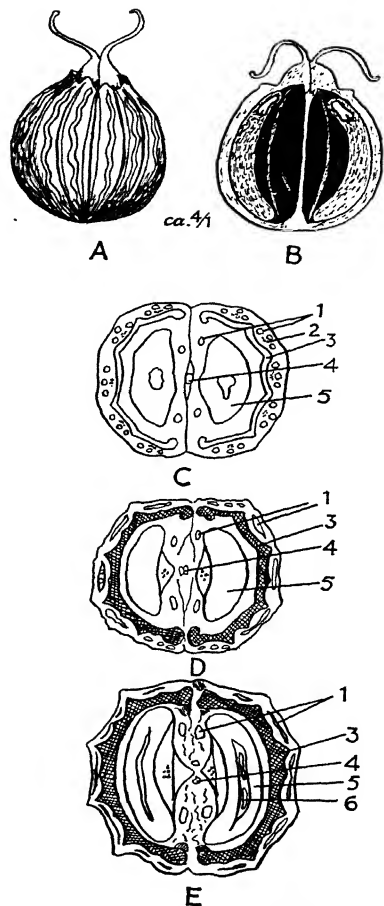


FIG. 182.—*Coriandrum sativum*. A, whole fruit; B, fruit cut longitudinally, showing embryo; C, transverse section of unripe fruit; D, transverse section of half-ripe fruit; E, transverse section of fully-ripe fruit. 1, vittæ; 2, vascular bundle; 3, sclerenchyma; 4, carpophore; 5, endosperm; 6, cotyledon. (C, D, and E after Tschirch.)

carp gradually join and are eventually compressed into slits. The outer part of the pericarp, which possesses stomata and prisms of calcium oxalate, is more or less completely thrown off. Within the vittæ-bearing region of the mesocarp a thick layer of sclerenchyma is formed, which consists of pitted, fusiform cells. The endosperm is curved and consists of parenchymatous cells containing fixed oil and aleurone grains. The latter contain rosettes of calcium oxalate $3-10\mu$ in diameter. For powder, see p. 99.

Constituents.—Coriander fruits contain up to 1 per cent. of volatile oil. This contains 65 to 70 per cent. of *d*-linalol (coriandrol) and pinene. The fruits yield 5 to 7 per cent. of ash.

The amount of volatile oil in the different varieties is approximately as follows:—Russian, 0.8 to 1 per cent.; Thuringian and Moravian, 0.6 to 0.8 per cent.; Dutch, 0.6 per cent.; Italian, 0.5 per cent.; French, 0.4 per cent.; Moroccan, 0.2 to 0.3 per cent., and East Indian, 0.15 to 0.2 per cent., The unripe plant has an unpleasant, mousey odour, which is also present in oil distilled from unripe fruits.

Uses.—Coriander is used as a flavouring agent and carminative. It is an ingredient of Compound Tincture of Rhubarb.

CARUI FRUCTUS

Carum, B.P. ; Caraway Fruit ; F. *Fruit de Carvi*, *Cumin des Prés* ; G. *Gemeiner Kümmel*

Source.—Caraway consists of the dried, ripe fruits of *Carum Carvi*, a biennial herb about 1 metre high. It occurs both wild and cultivated in Central and Northern Europe (Holland, Germany, Russia, Finland, Norway, Sweden, and England) and in Morocco.

History.—Caraway fruits were known to the Arabian physicians and probably came into use in Europe in the thirteenth century.

Macroscopical Characters.—The mericarps are usually separate and free from the pedicel. They are slightly curved, brown, and glabrous, about 4 to 7 mm. long and 1 to 2.3 mm. wide. Each mericarp shows five, almost equal sides, five, narrow primary ridges, and, when cut transversely, six vittæ. They have an aromatic odour and taste.

Microscopical Characters.—The epidermal cells have a very thick, striated cuticle. The mesocarp consists of more or less collapsed parenchyma and lacks the reticulated cells found in fennel. The vittæ are very large, attaining as much as 350μ in width. The endosperm is not grooved and contains fixed oil, aleurone, and calcium oxalate.

Constituents.—Caraways contain 3 to 7 per cent. of volatile oil, 8 to 20 per cent. of fixed oil, proteins, calcium oxalate,

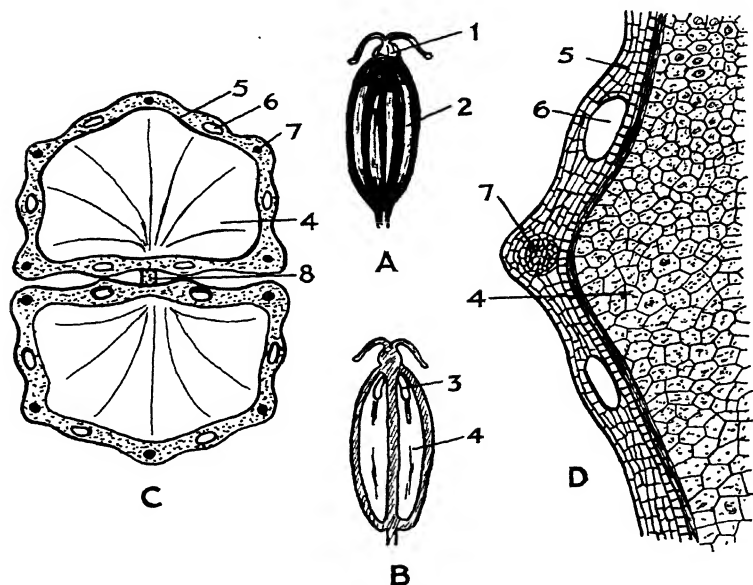


FIG. 183.—Caraway fruit. A, whole fruit; B, the same in longitudinal section; C, transverse section; D, portion of the same further enlarged. 1, stylopod; 2, ridge; 3, embryo; 4, endosperm; 5, pericarp; 6, vitta; 7, fibro-vascular bundle; 8, carpophore. (After Berg.)

colouring matter, and resin. They yield about 7.5 per cent. of ash (official limit, 9 per cent.).

The volatile oil (*Oleum Carui*, B.P.) consists of the ketone carvone (sp. gr. 0.850) and the terpene limonene (sp. gr. 0.964) with small quantities of dihydrocarvone, carveol, and dihydrocarveol. As there is a demand for pure carvone there is a considerable amount of de-carvonised oil available

for adulteration. The official oil is required to contain 53 to 63 per cent. of carvone when estimated by the Pharmacopoeial method.

Uses.—Large quantities of caraway fruits are used for culinary purposes. The fruits and oil are used in medicine for flavouring and as carminatives.

ANETHI FRUCTUS

Anethum, B.P.; Dill Fruit; F. *Fenouil Puant*; G. *Dill*

Source.—Dill consists of the dried, ripe fruits of *Anethum graveolens* Linn., a small annual indigenous to South Europe. It is cultivated in England, Germany, and Roumania.

History.—Dill was known to Dioscorides. It was employed in England in Anglo-Saxon times.

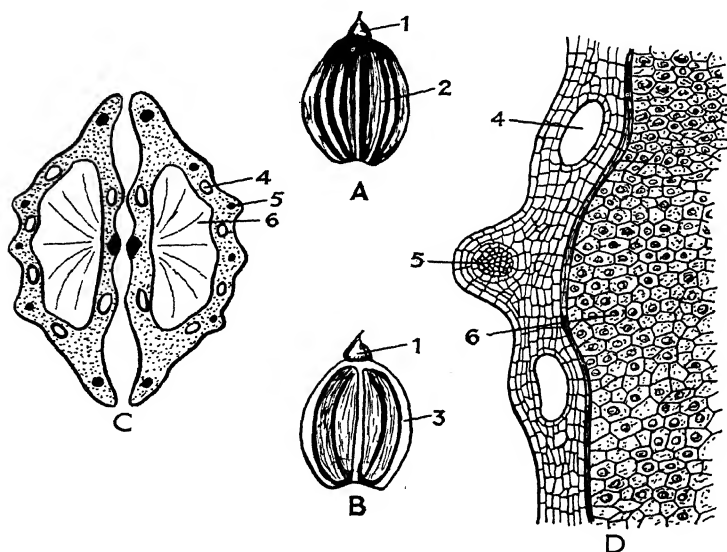


FIG. 184.—Dill. A, whole fruit; B, commissural surface of mericarp; C, transverse section of fruit; D, a portion of the same enlarged. 1, stylopod; 2 ridge; 3, wing; 4, vitta; 5, fibrovascular bundle; 6, endosperm. (After Berg.)

Macroscopical Characters.—The drug usually consists of separate, broadly oval mericarps, about 4 mm. long and 2 to 3 mm. broad. The fruits are very much compressed dorsally, the two ventral ridges being prolonged into membranous wings while the dorsal ones are inconspicuous. The fruits have an aromatic odour and taste.

Microscopical Characters.—Each mericarp has four vittæ on the dorsal surface and two on the commissural. The outer epidermis has a striated cuticle (distinction from fennel), and the mesocarp contains lignified, reticulate parenchyma (distinction from caraway). The endosperm is much flattened but otherwise resembles that of the fruits considered above.

Allied Drug.—*Indian dill*, derived from *Anethum Sowa*, has been imported as a substitute for *caraway*. The drug usually consists of whole cremocarps which bear pedicels and are narrower and less compressed than the European.

Constituents.—The chief constituent is the volatile oil (Oleum Anethi, B.P.). This resembles oil of caraway in containing carvone and limonene. The European fruits yield about 3 to 4 per cent. of volatile oil, which is officially required to contain from 43 to 63 per cent. of carvone.

Indian and Japanese dills (*A. Sowa*) yield oils which contain much less carvone than the European. These oils contain dill-apiol and are not official.

ANISI FRUCTUS

Anisum; *Anise Fruit*; F. *Anis*, *Anis Vert*; G. *Anissame*

Source.—Anise consists of the dried, ripe fruits of *Pimpinella Anisum*, an annual plant indigenous to the Levant but widely cultivated both in Europe (Spain, Germany, Italy, Russia, Macedonia) and America (Chili, Mexico).

History.—Anise is mentioned in the writings of Theophrastus, Dioscorides, and Pliny. It was cultivated in Germany in the ninth century.

Macroscopical Characters.—The drug consists of greyish-brown, pear-shaped, somewhat compressed cremocarps, which are usually attached to pedicels 2 to 12 mm. in length. The cremocarps are 3 to 6 mm. long and 2 to 3 mm. broad. The Spanish (Alicante) and Italian are distinguished by their large size and light colour, while the German and Russian are smaller, more ovoid, and darker. Each mericarp has five, somewhat

wavy ridges and is slightly pubescent on the dorsal surface. They have an aromatic odour and a sweet, aromatic taste.

Microscopical Characters.—Microscopical examination shows that the epidermis bears numerous papillæ and unicellular hairs. On the dorsal surface of each mericarp are from fifteen to forty-five branched vittæ. A small amount of vascular tissue and reticulated parenchyma is present. The endosperm is slightly concave on the commissural surface and contains protein and fixed oil.

Constituents.—Anise fruits yield 2 to 3 per cent. of volatile oil (*Oleum Anisi*, B.P.), which is practically identical with that obtained from the star-anise, *Illicium verum* (see p. 327). The *Pimpinella* oil is said to have a slightly superior flavour, but most of the anise oil used is that obtained from the star-anise.

Adulterants.—Anise fruits may be contaminated with other umbelliferous fruits or with earth. Hemlock has been found in Italian samples but is easily detected in the whole drug. If in powder, its presence may be detected by the change in odour on moistening with solution of potassium hydroxide. Coriander and an umbelliferous fruit which closely resembles anise, is said to occur in Russian samples. The ash should not exceed 11 per cent.

CUMINI FRUCTUS

Cummin Fruit ; F. *Cumin* ; G. *Kreuzkümmel Mutterkümmel*

Source.—Cummin consists of the dried, ripe fruits of *Cuminum Cuminum*, a small, annual plant indigenous to Egypt. It is widely cultivated and English supplies are obtained from Sicily, Malta, Mogadore, and India.

Characters.—Cummin fruits are about 6 mm. long and resemble caraway at first glance. The mericarps are, however, straighter than those of caraway and are densely covered with short, bristly hairs. Whole cremocarps attached to short pedicels occur, as well as isolated mericarps. Each mericarp has four dorsal vittæ and two commissural ones. The odour and taste are coarser than those of caraway.

Constituents.—Cummin yields 2.5 to 4.0 per cent. of volatile oil. This contains 25 to 35 per cent. of aldehydes (cuminic aldehyde), pinene, and α -terpineol.

Uses.—Cummin was one of the commonest spices in the Middle Ages. It is now chiefly employed in veterinary practice.

SUMBUL RADIX

*Sumbul or Musk Root ; F. Racine de Sumbul ; G. Moschus-
oder Sumbulwurzel*

Source.—Sumbul consists of the dried rootstock and roots of one or more species of *Ferula*. During the present century the character of the drug has changed somewhat and it appears probable that whereas it was formerly obtained from *Ferula Sumbul* Hooker fil. it is now derived from *F. suaveolens* Aitch. and Hmsl. Both are plants about 1 to 2 metres high found in Turkestan and Afghanistan.

Characters.—The drug occurs in extremely light, cylindrical pieces up to 7 cm. in diameter and 10 cm. in length. The apex frequently bears the remains of two or more aerial stems. The root is covered with a thin, very tough, greyish or brownish cork. It breaks with a short, fibrous fracture and shows a spongy, fibrous, and much fissured interior. The scattered vascular strands seen in transverse section are comparable with those of other *Ferula* species. The drug has a slightly musky odour* and an aromatic, bitter taste.

Constituents.—According to Heyl and Hart† the root contains 17 per cent. of resinous matter and 1 per cent. of volatile oil. The resinous portion contains a phytosterol, fatty acids (angelic, valerianic, butyric, etc.), betaine, and umbelliferone, both free and combined as a glycoside.

Uses.—Sumbul is used in the treatment of hysteria and dysmenorrhœa. Although last official in the Pharmacopœia of 1898 the tincture is still occasionally prescribed.

ASAFÆTIDA

*Asafætida, B.P. ; Asafetida ; Devil's Dung ; F. Assa fætida ;
G. Asant, Stinkasant*

Source.—Asafetida is officially described as an oleo-gum-resin obtained by incision from the living rhizome and root of

* Those familiar with the pre-war drug state that it had a more distinct musk odour than that at present imported. It has also been suggested that there is a difference in the fluorescence in ultra-violet light. This, however, may be merely due to the difference in age between the samples examined.

† *Amer. J.P.*, 1916, 546.

Ferula foetida Regel, *F. rubricaulis* Boiss., and other species of *Ferula*.* *F. foetida* is found in Turkestan, *F. assa foetida* in the stony, salt wastes of Persia and Western Afghanistan, and *F. Narthex* in Western Tibet. These species attain a height of about 3 metres.

History.—It appears doubtful if the substance known to the ancients as *Laser* was the asafetida of modern commerce. Asafetida seems to have been introduced from the East by the Arabian physicians. It was used in Europe during the Middle Ages but to a much less extent than galbanum, sagapenum, and opopanax.†

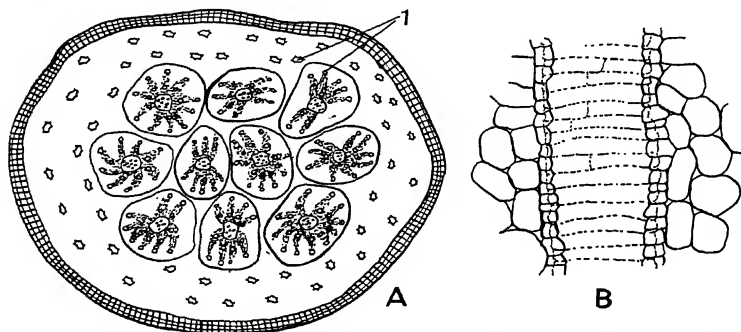


FIG. 185.—A, transverse section of old root of *Ferula assa foetida* showing the isolated vascular bundles and secretory ducts; B, longitudinal section through a schizogenous secretory duct of a species of *Ferula*. 1, secretory ducts. (A after Goris, B after Tschirch.)

Collection and Preparation.—The root structure of *F. assa foetida* has been studied by Goris and Hérail. Schizogenous

* There still appears to be some doubt as to the exact botanical origin of both asafetida and galbanum. Recent Continental text-books adopt the view that asafetida is derived from *Ferula assa foetida* L., *F. foetida* Regel, and *F. Narthex* Boiss., and that galbanum is derived from *F. galbaniflua* Boiss. et Buhse, *F. rubricaulis* Boiss., and *F. Schir* Boiss.

In Planchon's *Matière Médicale*, p. 1051, the statement that *F. rubricaulis* is a source of galbanum and not asafetida is qualified by the following footnote:—"L'accord n'est pas encore complet sur le produit de cette espèce. Greenish la considère comme une source d'asa foetida, elle donnerait en particulier les larmes qui restent blancâtres avec le temps et dont la couleur de la cassure reste à peu près blanche." The view taken by Greenish is supported by the investigations of Small, P.J., 1913, [4], 36, 287, who gives a comparative account of the structures of the fruits of authentic species of *Ferula* and compares them with the fruits found in the commercial drugs.

† Sagapenum and opopanax are no longer common. They are described in the *Pharmacographia*.

resin canals are very abundant, a double row being present in the cortex and others in the vascular strands (see Fig. 185).

The collection of asafetida has been observed by Kämpfer (1687) in Laristan (see Fig. 162), and by Bellew (1857) and Wood (1872) in Khorasan and Afghanistan. The details of collection vary in different localities. The following information supplied to us by H.M. Consul at Shiraz in a letter dated 1935 may be compared with the earlier accounts of Kämpfer, Bellew and Wood given in the *Pharmacographia*.*

"The plant grows in the more remote districts of Fars, and is a cane or reed about 7 to 10 feet in height. It is called 'anghuzeh,' as is also the product.

"Collection takes place in the late spring. The head of the plant is cut, when the exudation oozes out and is collected. The process is continued for a second and a third time, the plant being cut down lower on each occasion. The plants are cut with a saw. The best grade is obtained from the first cutting and the product of the third cutting comes next in quality, that from the second cutting being of poor quality."

The drug may be sent overland to India by the Khaiber or Bolan Passes or from the Persian Gulf ports. Most of the drug now appears to go by the latter route from ports such as Bundar Abbas to Bombay and thence to Europe. It usually arrives in tin-lined cases holding from 50 to 200 kilograms.

Characters.—Asafetida occurs in two principal forms:—

(1) *Tears*.—These are rounded or flattened and about 5 to 30 mm. in diameter. They are greyish-white, dull yellow, or reddish-brown in colour, some specimens acquiring the latter colour with age while others remain greyish or yellowish. The fractured surface either remains yellowish and translucent or gradually changes from an opaque milky-white through pink and red to reddish-brown. According to Greenish, "probably the red variety is derived from *F. fetida*, the white from *F. rubricaulis*." When the fractured surface is treated with sulphuric acid a red or reddish-brown colour is produced, which changes to violet when the acid is washed off with water, whilst with 50 per cent. nitric acid a green colour is

* *Pharmacographia*, p. 317. According to Kämpfer, collection starts in the middle of April, and its details are shown in a sketch reproduced in Tschirch's *Handbuch der Pharmakognosie* (1933), B 1, A 3, 1727. This shows the removal of the stem and of the soil surrounding the root. Commencing about forty days later, it shows the removal of the exudation and fresh slices of root with a broad iron spatula on three dates in May, six in June, and three in July.

PHARMACOGNOSY

obtained. Asafetida tears are harder than those of galbanum but softer than those of ammoniacum. They soften on warming.

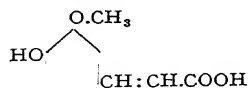
(2) *Mass.*—This consists of similar tears to those described above agglutinated into masses and usually mixed with fruits,* fragments of root, earth, and other impurities. Mass asafetida is the commonest commercial form.

Asafetida is much more readily powdered if it is first cooled. It has a strong, alliaceous odour and a bitter, acrid, and alliaceous taste. The Pharmacopœia requires that it shall yield not more than 50 per cent. of matter insoluble in alcohol (90 per cent.), and not more than 15 per cent. of ash.

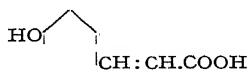
Constituents.—Asafetida consists of volatile oil, resin, gum, and impurities. The tears and lump both contain about the same amount of volatile oil, which has a particularly evil smell and contains sulphur compounds of the formulæ $C_7H_{14}S_2$, $C_{16}H_{20}S_2$, $C_8H_{16}S_2$, and $C_{10}H_{18}S_2$. Umney and Bunker (1910) found that the oil of the tears contains more sulphur than that from the mass. Ten samples of the oil examined by Harrison and Self (1912) had sulphur contents varying from 17.6 to 37.8 per cent.

According to analyses of Baumann (1919), asafetida has the following approximate composition :—Volatile oil and resene, 50.1 per cent. ; asaresinol ferulate, 16.57 per cent. ; free ferulic acid, 1.33 per cent. ; ether insoluble resin, 1 per cent. ; gum and impurities, 31 per cent.

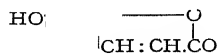
Asaresinol ferulate is an unstable ester of the phenolic body asaresinol. The drug contains no free umbelliferone (distinction from galbanum). On boiling it, however, with hydrochloric acid and filtering into ammonia a blue fluorescence is produced owing to the formation of umbelliferone. Ferulic acid is closely related to umbellic acid and umbelliferone (both of which occur in galbanum), as may be seen from the following formulæ :—



Ferulic acid
(hydroxymethoxy-
cinnamic acid)



Umbellic acid
(dihydroxycinnamic
acid)



Umbelliferone
(lactone of umbellic
acid)

* For illustrations of fruits, see Tschirch's *Handbuch der Pharmakognosie*, III, 2, 1078, and Small, *P.J.*, 1913, [4], 36, 287.

Uses.—Asafetida is used in hysterical conditions, as an expectorant in chronic bronchitis, and as a means of removing intestinal flatulence. Large quantities are used in veterinary work. Certain sauces are said to contain small proportions of asafetida.

GALBANUM

Galbanum; *F. Galbanum*; *G. Mutterharz*

Source.—Galbanum is an oleo-gum-resin obtained from *Ferula galbaniflua* Boiss. et Buhse, and other species of *Ferula*,* which have a similar distribution to those yielding asafetida. The drug reaches England *via* the Persian Gulf ports and Bombay.

Collection.—The method of collecting galbanum probably differs according to local conditions. Some, according to Buhse, is obtained by natural exudation from the stem, while the greater part is obtained by incising the root. In the latter case the earth is scraped away from the crown and slices of root are removed at intervals as described by Kämpfer for asafetida.

Characters.—Galbanum occurs in brownish tears, which are usually smaller than those of asafetida, or in agglutinated masses of tears with much vegetable debris. The usual lump galbanum, known as “Levant,” contains abundant slices of root and few fruits, while the less common “Persian” variety contains fruits and fruit stalks and is usually softer than the Levant. The fruits are something like those of dill in shape but are 10 to 12 mm. long. Galbanum is sufficiently soft for the tears to be flattened between the finger and thumb. It has a rather pleasant odour and a characteristic, disagreeable taste.

Free umbelliferone is present as is shown by the fact that a tincture gives a strong blue fluorescence when poured into an alcoholic solution of ammonia.

Constituents.—Analyses of galbanum show about 9·5 per cent. of volatile oil, 63·5 per cent. of alcohol-soluble resin, and 27 per cent. of gum and impurities. The resin contains 20 per cent. of combined umbelliferone, 0·25 per cent. of free umbelliferone, and about 50 per cent. of galbaresinotannol.

Uses.—Galbanum is used in plasters and, with asafetida, in *Pilula Galbani Composita*, B.P. 1898.

* See footnote to asafetida, p. 532.

AMMONIACUM

Ammoniacum ; *Persian Ammoniacum* ; F. *Gomme*
Ammoniaque ; G. *Ammoniakgummi*

Source.—Ammoniacum is an oleo-gum-resin obtained from the flowering and fruiting stem of *Dorema Ammoniacum* Don, and probably other species such as *D. Aucheri* Boiss. It is chiefly collected in Central Persia and sent to Ispahan, whence it passes *via* the Persian Gulf ports to Bombay.

Collection.—The secretion collects on the stem in May and June either as the result of punctures made by insects, which visit the flowering and fruiting plants, or from incisions specially made with a view to collecting the drug (Kennett). Some of the secretion fails to harden on the stem and is collected from the ground. Of the two forms, tear and lump, only the former was admitted to the 1914 Pharmacopœia.

Characters.—Ammoniacum occurs in yellowish, more or less rounded tears about 5 to 25 mm. in diameter. They are harder than those of galbanum but soften on warming. The freshly fractured surface is waxy and yellowish-white. The lump form contains pieces of stem, fruits, and earthy impurities.

Ammoniacum is characterised by the fact that the emulsion, formed when the drug is triturated with water, gives a deep orange-red colour on the addition of solution of chlorinated soda ; also, by the fact that it contains neither free nor combined umbelliferone.

Constituents.—Ammoniacum normally contains 0.08 to 0.30 per cent. (occasionally up to 6 per cent.) of volatile oil, 60 to 70 per cent. of resin, about 20 per cent. of gum and a variable amount of moisture and impurities.

According to Casparis (1924) and Casparis and Michel (1928) the resin contains ammoresinol, a crystalline compound melting at 110.5°. This compound has one phenolic hydroxy group and two methoxy groups ; it is the cause of the orange-red colour with chlorinated soda solution.

Uses.—Ammoniacum has similar properties to asafetida and galbanum.

CHAPTER XXI

Phylum **ANGIOSPERMÆ** ; Subphylum **DICOTYLEDONS**

Grade C. **Sympetalæ**

Order **ERICALES**

An order consisting of five families, of which the most important is the *Ericaceæ*.

Family **ERICACEÆ**

The *Ericaceæ* comprises about 1350 species belonging to about 99 genera, of which may be mentioned *Vaccinium* (bilberry), *Erica* (heaths and heathers), *Rhododendron*, *Gaultheria* and *Arctostaphylos*. Natural oil of wintergreen was formerly obtained from the leaves of *Gaultheria procumbens* (*Ericaceæ*), but is now distilled from the bark of *Betula lenta* (*Betulaceæ*).

UVÆ URSI FOLIA

Uva Ursi ; Bearberry Leaves ; F. *Feuilles de Busserole* ;
G. *Bärentraubenblätter*

Source.—Bearberry consists of the dried leaves of *Arctostaphylos Uva-ursi*, a small evergreen shrub found in Central and Northern Europe and in North America.

Characters.—The leaves are dark green to brownish-green, 2 to 3 cm. long, obovate or spatulate, gradually narrowing to a very short petiole. They are coriaceous in texture and, excepting the very young ones, almost glabrous. The upper surface is shining and marked with sunken veinlets ; the lower surface is lighter and marked with a network of dark veinlets. Large stomata surrounded by 4 to 7 cells (Fig. 42, C) are present on the lower surface only. The drug is odourless but has an astringent and somewhat bitter taste.

Constituents.—Bearberry contains the glycosides arbutin and methylarbutin, about 6 to 7 per cent. of tannin, gallic acid, ellagic acid, ursone and the flavone derivative quercetin. Arbutin occurs in white needles which are readily soluble in water and alcohol. When hydrolysed with acids or emulsin it yields glucose and hydroquinone. Partial hydrolysis takes place in the body.

Uses.—Bearberry is diuretic and astringent, and is used in diseases such as urethritis and cystitis. During excretion it exerts an antiseptic action on the urinary tract.

Order EBENALES

AN order consisting mainly of tropical, woody plants. It includes the families Sapotaceæ and Styracææ.

Family SAPOTACEÆ

A family of 40 genera and about 600 species, most of which are trees. Latex sacs are found in the leaves and in the cortex, phloem, and pith of the stems.

GUTTAPERCHA

Source.—Guttapercha is a purified, coagulated latex obtained from trees of the genera *Palaquium* and *Payena*. The chief of these are *Palaquium oblongifolium*, *P. borneense*, *P. Treubii* and *Payena Leerii*, large trees which are found both wild and cultivated in Malaya, particularly in Sumatra and Borneo.

Collection and Preparation.—Formerly the trees were felled and incisions then cut in the bark, the fragments of coagulated latex being afterwards scraped out. The name is derived from the Malay *gutta*, gum, and *percha*, scraps or rags. The more modern method of collection resembles that used for rubber. V-shaped or other types of incision are made in the bark of the living trees and the latex collected in cups. Guttapercha is also prepared from the leaves by means of solvents such as toluene.

Guttapercha differs from rubber in being almost incapable of vulcanisation, and in that it becomes plastic when heated to about 45° to 60°. The latter property is utilised for its

purification. It is shredded, kneaded under hot water, and forced while plastic through a wire sieve. It is easily made into thin sheets. When so prepared it is brown, but a white guttapercha may be prepared by decolorising a chloroformic solution with charcoal, filtering and precipitating with alcohol.

Guttapercha is soluble in cold chloroform and carbon disulphide and in warm benzene or oil of turpentine.

Constituents.—Guttapercha contains a white, crystalline hydrocarbon, gutta, $C_{30}H_{48}$, which gradually turns red on exposure to air. Other constituents are an unstable substance called guttan and complex crystalline substances known as alban, albanans, and fluavils. The latter appear to differ according to the source of the guttapercha.

Uses.—Guttapercha is used in the form of a chloroformic solution as a means of applying such drugs as chrysarobin to the skin, or as guttapercha tissue for covering moist dressings. White guttapercha is used for temporarily stopping teeth.

Family STYRACEÆ

A family of eight genera and about 120 species, of which 100 belong to the genus *Styrax*.

BENZOINUM

Benzoinum, B.P. ; *Benzoin*, *Gum Benjamin* ; F. *Benjoin* ;
G. *Benzoëharz*

Source.—Official benzoin is that known in commerce as Sumatra benzoin. It is a balsamic resin obtained by making incisions in the stem of *Styrax Benzoin* Dryand, and possibly *S. matranus* J. J. Smith. The trees are cultivated throughout Sumatra and the drug is exported from Palembang. The U.S.P. XI also admits benzoin from *S. tonkinensis* or other species known in commerce as Siamese benzoin.

History.—The drug was noted by Ibn Batuta, who visited Sumatra in the fourteenth century, but it does not appear to have been regularly imported into Europe until the sixteenth century.

Collection and Preparation.*—(1) Benzoin is a purely pathological product and there is some evidence to show that its formation is brought about not only by the incisions made,

* The following account is derived from an abstract in the *P.J.*, 1926, [4], 59, of an article by F. Reinitzer, *Archiv. der Pharmazie*, vol. 264, p. 368.

but also by fungi. The seeds are sown in rice fields, the rice shading the young trees during their first year. After the harvesting of the rice the trees are allowed to grow until they are about seven years old.

Tapping.—"In Palembang the tapping is conducted by dividing the surface of the stem of the tree by the eye into three equal vertical strips. In each of these strips three small, gaping wounds are made, the lowest about 40 cm. from the ground and the two others directly above it at distances of about 40 cm. Each wound is made by a single blow of a knife, which cuts out a triangular piece of bark and a thin layer of wood. The bark between the wounds is then scraped smooth. In about a week's time a yellowish sap begins to exude and collect in and on the wounds, assuming under the influence of light and air a brownish colour. After about a month, grains resembling the almonds of benzoin can be distinguished in it, but the mass is still soft and extraordinarily sticky. After a month and a half to two months it becomes less sticky and sufficiently hard to allow of its being collected. The product of the first and often of the second hacking is, however, worthless, and is not collected, but carefully removed with the knife. This first resin is completely amorphous, whereas the milky-white resin that subsequently flows is entirely crystalline. The grains that appear in the amorphous resin are evidently the beginning of the production of crystals which ultimately lead to the production of a milky-white resin. After the amorphous resin has been removed, a second incision is made about 4 cm. above each old incision, and an additional one about 40 cm. above the highest of the three old incisions. Every three months the number of incisions is increased in this way, until they make a continuous line, when another row is started a little to the left or right. In this way the tapping is continued until the tree dies. . . ."

Collection.—"The resin is removed either with the knife or with a sharpened bamboo or a piece of tin-plate. The outer layers are first removed without touching the bark, the knife being moved from below upwards. This gives the finest quality, which is pale in colour and free from bits of bark. In Palembang it is called 'mĕnjan putih' (white) or 'mĕnjan sodokan,' and is usually collected about six weeks after the tapping. About a fortnight later the remaining layers are taken off down to the bark; this is distinctly darker, as it has had more time to oxidise, contains fragments of bark, and is less valuable. It is called 'mĕnjan sesetan' or 'mĕnjan itam baik' (black, good). After another month, just before the new incisions are made, the bark of the tree is scraped, by which more bark than resin is removed, and the poorest, very dark quality, 'mĕnjan itam djahat,' obtained. . . ."

FIG. 186.—Diagram showing one strip of incisions. 1, 2 and 3 the first, second and third series of cuts. A B the first zone of bark to be scraped smooth.

Grades.—"These three chief qualities are sent separately, in little barrels made of bark, to Palembang. . . . These varieties are mixed together in the export towns, as the best qualities would be too dear for use in the interior, and the poorer qualities would not realise sufficiently high prices. The blocks of resin are hacked into pieces. The better qualities are mixed and stamped into tins lined with thin linen. These are then placed in the sun, by which the resin is softened and unites to form a solid mass. The linen is then folded over on the top. In this way benzoin with almonds is produced. The lowest qualities cannot be so treated, as they contain so much bark that the resin will not unite into a mass; they are finely hacked and thrown into water, when impurities float on the surface and can be skimmed off. For mixing with other qualities it is softened in boiling water; a small quantity of each of the varieties to be mixed is then softened in hot water, the whole mixed with constant stirring, thrown into a tin-lined case and stamped in.

"In this way three varieties of almond benzoin are produced. The best contains abundance of white almonds but with little matrix; in the second and major part is brown matrix with fewer almonds, while in the third quality the almonds are sparsely distributed in a brown, friable matrix, with abundant fragments of bark."

Characters.—Sumatra benzoin occurs in brittle masses consisting of opaque, whitish or reddish tears embedded in a translucent, reddish-brown or greyish-brown, resinous matrix. Odour, agreeable and balsamic, but not very marked; taste, slightly acid.

When gradually heated benzoin evolves white fumes of cinnamic and benzoic acids, which readily condense on a cool surface as a crystalline sublimate. On warming a little powdered benzoin with solution of potassium permanganate a faint odour of benzaldehyde is noted, showing the presence of an appreciable amount of cinnamic acid (distinction from Siamese benzoin). Alcohol (90 per cent.) dissolves about 85 per cent. of the drug.

Constituents.—Benzoin consists of resin, free cinnamic acid (about 11 per cent.), free benzoic acid (about 9 per cent.), styrene (phenylethylene), phenylpropyl cinnamate, cinnamyl cinnamate, vanillin, and benzaldehyde.

The resin consists of cinnamic and benzoic acids combined with *d*-sumaresinolic acid, *d*-siaresinolic acid (benzoresinol or siaresinol, $C_{16}H_{28}O_2$), and a resinetannol, $C_{18}H_{20}O_4$. The drug contains about 26 to 35 per cent. of total balsamic acids, but the proportion of the various constituents varies considerably in the different commercial grades.

Allied Drugs.—*Siamese benzoin* is probably obtained from *Styrax tonkinense* Craib, a tree grown in Siam (Laos), North

Annam, and Tonkin. This drug is official in many pharmacopœias, *e.g.* the U.S.P. XI, and fetches a higher price than the Sumatra variety. It occurs in tears or in blocks. The tears are of variable size and flattened; they are yellowish-brown or reddish-brown externally, but milky-white and opaque internally. The block form consists of small tears embedded in a somewhat glassy, reddish-brown, resinous matrix.

Siamese benzoin contains crystalline coniferyl benzoate (about 68 per cent.), amorphous coniferyl benzoate (about 10 per cent.), free benzoic acid (about 12 per cent.), free *d*-siaresinolic acid (about 6 per cent.), vanillin (0.3 to 2.3 per cent.), cinnamyl benzoate and siaresinotannol.

According to Cocking and Kettle (1914) the amount of balsamic acids present is about 39 per cent. The drug gives no odour of benzaldehyde when warmed with solution of potassium permanganate.

Palembang benzoin is an inferior variety of benzoin produced in Sumatra. According to the abstract of Reinitzer's article previously referred to, "A fourth quality is occasionally collected from isolated trees from which the resin has not been stripped for some time. This resin is hard and dry and covered with a dirty, black layer; it is knocked off the tree, softened and washed in river water, and then softened in hot water." Possibly this is the commercial Palembang benzoin. It is easily distinguished from the official drug, being very light in weight and breaking with an irregular porous fracture. It consists almost entirely of reddish-brown resin, only a few very small tears being embedded in it. Palembang benzoin is used as a source of natural benzoic acid.

Uses.—Benzoin, when taken internally, acts as an expectorant and antiseptic. It is mainly used as an ingredient of Friar's Balsam, or as a cosmetic lotion prepared from a simple tincture.

The remaining sympetalous orders are known as the Tetracyclæ since the flowers have four whorls, a single whorl of stamens alternating with the petals. The orders are grouped, according to whether the ovary is superior or inferior, into :—

- (a) **Superæ.**—Orders Oleales, Contortæ, Convolvulales, Tubifloræ, and Plantaginales; and
- (b) **Inferæ.**—Orders Rubiales and Campanulales.

Order OLEALES

A small order including the Oleaceæ and Salvadoraceæ.

Family OLEACEÆ

A family of 22 genera and about 400 species of woody plants. Of these the ash and privet are indigenous to Britain, and the lilac, *Jasminum*, and *Forsythia* are commonly cultivated.

OLEUM OLIVÆ

Oleum Olivæ, B.P. ; *Olive Oil*, *Salad Oil*, *Sweet Oil* ;
F. *Huile d'Olive* ; G. *Olivenöl*

Source.—Olive oil is a fixed oil which is expressed from the ripe fruits of *Olea europæa*. The olive is an evergreen tree, which lives to a great age but seldom exceeds 12 metres in height. It produces drupaceous fruits about 2 to 3 cm. in length. The var. *latifolia* bears larger fruits than the var. *longifolia*, but the latter is said to yield the best oil. The oil is expressed in all the Mediterranean countries and in California.

History.—The olive appears to be a native of Palestine. It was known in Egypt in the seventeenth century B.C., and was introduced into Spain at an early period.

Collection and Preparation.—The methods used for the preparation of the oil naturally vary somewhat according to local conditions. In the modern factories hydraulic presses are widely used, but in the more remote districts the procedure is essentially that which has been followed for hundreds of years. A small, peasant-owned, Italian plant visited by the author was situated in a valley surrounded by olive terraces and a small stream turning a paddle-wheel provided the power for working the stone edge-runner mill which ground the fruits. The olives are gathered from about November to April, according to the district. After grinding, the pulp is introduced into coarse, grass baskets known as "fiskoloes" * (Fig. 187), and a number of these are placed in a screw press. In the one we examined, the final pressure was applied by attaching a rope to the end of the lever actuating the screw and winding this on a capstan. The oil which escapes is run

* This word affords some indication of the antiquity of the process since *fiscus*, -i, is used by Columella, a writer on husbandry of about A.D. 50, to denote a basket used in the pressing of olives.

into tubs containing water and the upper layer skimmed off. The product is known as virgin oil. The marc is then treated with water and again expressed, when it yields a further quantity of oil. In the large factories the marc may be extracted with solvents, but the peasants usually allow it to dry and use it for fuel.

Characters.—Olive oil is a pale yellow liquid, which sometimes has a greenish tint. The amount of colouring matter present, whether chlorophyll or carotene, appears to determine

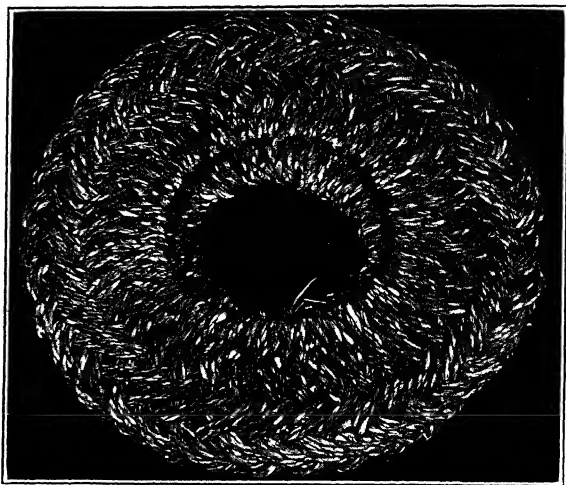


FIG. 187.—Grass basket or "Fiskolo" used in the expression of olive oil (Sutcliffe).

the natural fluorescence of the oil in ultra-violet light. To what extent the fluorescence may be modified by adulterants, heat refining, solvent extraction, etc., is a subject which has been much discussed in recent years.*

The oil has a slight odour and a bland taste. It should comply with the official tests for absence of cotton-seed oil, sesame oil, and arachis oil. If the fruits used have been allowed to ferment the acid value of the oil will be higher than is officially permitted.

* For a summary and reference to literature, see Radley and Grant, *Fluorescence Analysis in Ultra-Violet Light*.

Constituents.—Olive oil consists chiefly of olein. It also contains linolein, palmitin, and arachin, the latter frequently separating in cold weather.

Uses.—Olive oil is used in the preparation of soaps, plasters, etc., and is widely employed as a salad oil.

MANNA

Flake Manna, Ash Manna ; F. Manne ; G. Manna

Source.—The name manna is applied to a number of different, saccharine exudations. The only manna of commercial importance, however, is ash manna, the product of *Fraxinus Ornus*. The manna ash is a small tree of common occurrence in the Mediterranean, but the drug is almost entirely collected in Sicily.

Collection.—When the trees are about ten years old, transverse incisions are made in the stem with a knife which is curved to about the same extent as the bark through which it cuts.* The first incision is made in July or August near the base of the trunk, and further incisions are then made daily above this at intervals of about 4 or 5 cm. One side of the tree is incised each year. The sugary exudation either dries on the stem and is picked off (flake manna), or is caught on leaves or tiles. The manna is further dried and sorted before entering commerce in tins.

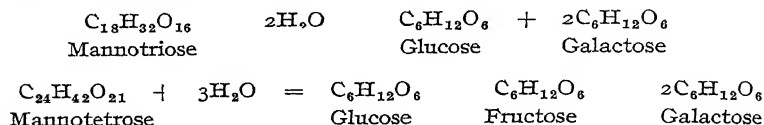
Characters.—Manna occurs in yellowish-white, somewhat triangular pieces up to 15 cm. long and 2.5 cm. wide, or in more or less agglutinated masses of broken flakes. It is sticky, but breaks with a brittle, crystalline fracture. The solid or an aqueous solution shows a blue fluorescence in ultra-violet light. The drug has a pleasant odour and a sweet taste.

Constituents.—According to Tanret, manna contains about 55 per cent. of the hexahydric alcohol, mannitol or mannite, $C_6H_8(OH)_6$, 10 per cent. of water, 2.2 per cent. of glucose, 2.5 per cent. of fructose, 6 per cent. of mannotriose, 12 per cent. of mannotetrose, 0.05 per cent. of resin and the fluorescent glycoside, fraxin.

* See Tschirch's *Handbuch der Pharmakognosie*, for a photograph showing the making of the incisions.

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The sugars mannotriose and mannotetrose can be hydrolysed according to the equations :—



Uses.—Manna is used as a laxative for children.

Order CONTORTÆ

An order consisting of the families Loganiaceæ, Gentianaceæ, Apocynaceæ, and Asclepiadaceæ. In these families the corolla segments show twisted aestivation and internal phloem is of general occurrence. Latex tubes are absent in the Loganiaceæ and Gentianaceæ, but are present in the other two families.

Family LOGANIACEÆ

A family consisting of 33 genera and about 600 species. The members are herbs, shrubs, lianes and trees. About 150 species belong to the genus *Strychnos*. In addition to the drugs described below, curare must be mentioned.

Curare is the name applied to extracts made from the barks of various species of *Strychnos*. These extracts are prepared by South American tribes as arrow-poisons. Para curare, the variety now seen in commerce, occurs in bamboos. It contains the alkaloids curine and tubocurarine.

NUCIS VOMICÆ SEMEN

Nux Vomica, B.P., *Strychni Semen*, I.A. ; *Nux Vomica* ;
F. *Nux Vomique* ; G. *Krahenaugen*, *Brechmuss*

Source.—*Nux vomica* consists of the dried, ripe seeds of *Strychnos Nux-vomica*, a tree 10 to 13 metres high found from India to North Australia. It is also cultivated in Africa (Cameroons). The drug is mainly collected in the Madras Presidency and exported from Bombay, Madras, Cochin, Cocanada, and Calcutta.

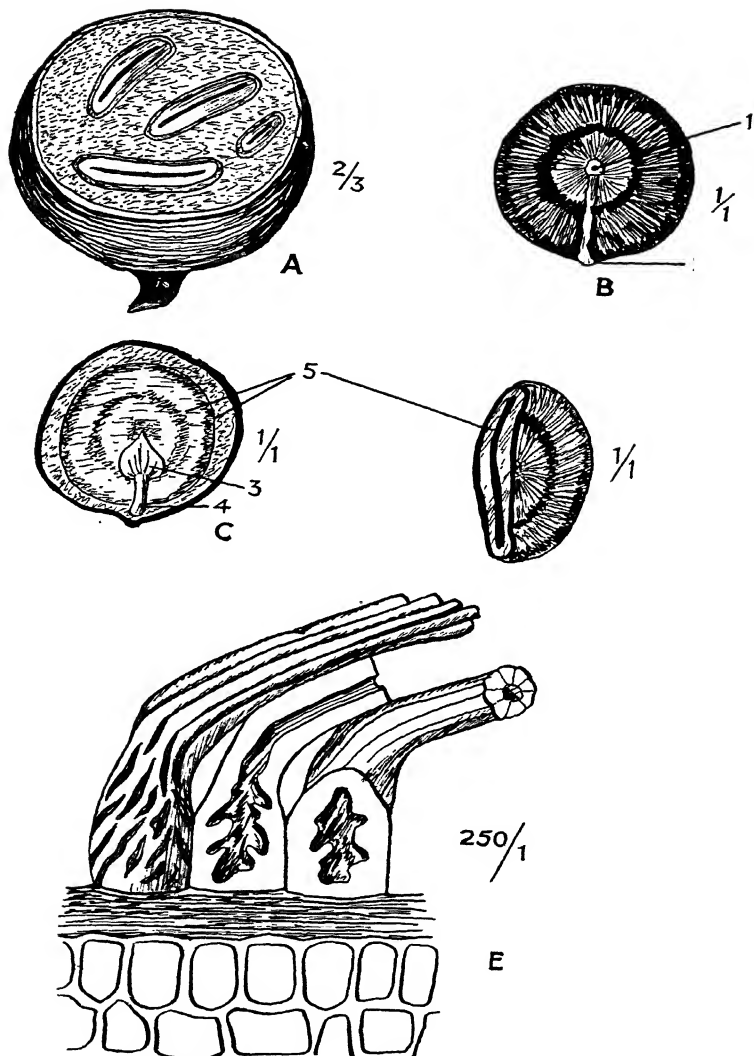


FIG. 188.—*Strychnos Nux-vomica*. A, ripe fruit in transverse section; B, seed; C, seed split longitudinally; D, seed cut radially; E, radial section of outer part of the seed. 1, hilum; 2, micropyle; 3, cotyledon; 4, radicle; 5, endosperm. (A after Luerksen, E after Gilg.)

Collection and Preparation.—The fruit is a berry about the size of a small orange. When ripe it has a rather hard orange-yellow epicarp and a white, pulpy interior in which from one to five seeds are embedded. The seeds are washed free from pulp and dried. They are exported in small sacks, known as "pockets," holding from 40 to 56 lb.

History.—*Nux vomica* was known in Europe in the sixteenth century and was sold in England in the time of Parkinson (1640), mainly for poisoning animals. Strychnine was discovered in 1817 and brucine in 1819.

Macroscopical Characters.—*Nux vomica* seeds are extremely hard and should be boiled in water for at least an hour in order to soften them sufficiently for dissection. The seeds are greenish-grey or grey in colour, disc-shaped, 10 to 30 mm. in diameter, and 4 to 6 mm. in thickness. Most of the seeds are nearly flat and regular in shape, but a few are irregularly bent and somewhat oval in outline. The edge is rounded or acute. The testa is covered with silky, closely appressed, radiating hairs. In the centre of one of the flattened sides is a distinct hilum and a small prominence on the circumference marks the position of the micropyle, which is joined to the hilum by a raised ridge. A boiled seed should be cut transversely and another one opened like an oyster by inserting the blade of a small knife or scalpel at a point on the circumference opposite the micropyle (see Fig. 188, C and D). The small embryo with two cordate cotyledons and a cylindrical radicle, the latter directed towards the micropyle, will be seen embedded in a grey, horny endosperm. In the centre of the seed is a slit-like cavity. The seeds are odourless when dry, but if soaked in water and left for a day or two they develop a very unpleasant odour. They have a very bitter taste.

Microscopical Characters.—A radial section (Fig. 188, E) shows a very thin testa consisting of collapsed parenchyma and an epidermal layer of very characteristic lignified hairs. The latter have a very large, thick-walled base with slit-like pits. Surface irregularities in the bases of the hairs cause them to interlock with one another. The upper portions of the hairs are all bent in the same direction, and give the testa its characteristic silky appearance. The upper part of the wall of the hair has rod-like thickenings which readily separate from one another on powdering. The lumen is circular in the upper part, but in the base has branches corresponding with the oblique pits in the wall. Fragments of testa, removed

from a soaked seed, may be disintegrated by treatment with 50 per cent. nitric acid and a little potassium chlorate; the hairs then separate from one another on vigorous shaking.

The endosperm consists of large, thick-walled cells, which swell if the seeds have been boiled or treated with solution of potassium hydroxide. The walls are non-lignified and are of carbohydrate nature since they yield galactose and mannose on hydrolysis. When mounted in solution of iodine they show well-marked protoplasmic threads (plasmodesma) passing through the walls and an oily plasma containing a few aleurone grains and the alkaloids strychnine and brucine. Strychnine is most abundant in the inner part of the endosperm and brucine in the outer layers. The presence of strychnine is shown by mounting a section in a solution of ammonium vanadate in sulphuric acid, when a violet colour is produced; and brucine by mounting in nitric acid, when a crimson colour is observed. For powder, see p. 101.

Constituents.—*Nux vomica* usually contains about 2 to 3.5 per cent. of the alkaloids, strychnine and brucine. Strychnine is much more physiologically active than brucine, and the seeds are therefore assayed for strychnine and not for total alkaloids. They usually contain about 1.23 per cent of strychnine (official minimum 1.2 per cent.) and about 1.55 per cent. of brucine. The seeds also contain chlorogenic acid (caffeotannic acid), a glycoside (loganin), and about 3 per cent. of fixed oil.

Uses.—The action of the whole drug closely resembles that of strychnine. The alkaloid is used as a circulatory stimulant in surgical shock, etc., and is valuable in certain cases of poisoning. Like other bitters strychnine improves the appetite and digestion, but it has been considerably misused as a "general tonic."

Allied Drugs.—*Ignatius beans* are the seeds of *Strychnos Ignatii*, a plant indigenous to the Philippines, but now grown in Cochin China. The fruits are larger than those of *nux vomica*, and may contain as many as thirty seeds. These are about 25 mm. long, dark grey in colour, and irregularly ovoid in shape. The structure closely resembles that of *nux vomica*, but the testa, which bears irregularly arranged greyish hairs, is easily rubbed off, and is almost entirely absent in the commercial drug. The seeds contain about 2.5 to 3.0 per cent. of total alkaloids, of which about 46 to 62 per cent. is strychnine. They are mainly used for the preparation of strychnine and brucine.

The seeds of *S. Tieute*, a Javanese species, contain about 1.4 per cent. of strychnine and a little brucine. *S. ligustrina* (bark and wood), *S. Rheedii* (seeds), and *S. aculeata* (seeds) contain brucine but no strychnine.

S. potatorum, from India, and *S. Nux-blanda*, from Burma, although containing no alkaloids, have been substituted for nux vomica. They are best distinguished by means of the ammonium vanadate reagent. The seeds of *S. potatorum* are used in India for clearing water, whence the specific name.

GELSEMII RADIX

Gelsemium; *Gelsemium* or Yellow Jasmine Root; F. *Jasmin Sauvage*; G. *Gelsemie*, *Giftjasmin*

Source.—Gelsemium consists of the dried rhizomes and roots of the American yellow jasmine, *Gelsemium nitidum*. It is collected in the autumn in the southern United States.

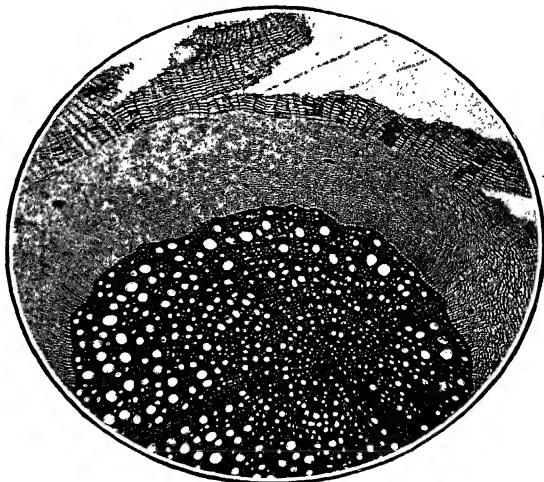


FIG. 189.—*Gelsemium nitidum*. Transverse section of root (Sutcliffe).

Characters.—The drug occurs in cylindrical pieces from 3 to 20 cm. in length and from 3 to 30 mm. in diameter. The outer cork cells of the rhizome are reddish-brown and the inner ones yellowish. As growth takes place the outer cork

cells crack and the inner cork shows itself as a yellowish-brown reticulation. The roots are somewhat smaller than the rhizome and have a uniform yellowish-brown cork. Gelsemium breaks with an irregular splintery fracture. It has a slightly aromatic odour and a bitter taste.

A transverse section of the rhizome shows a thick cork, a cortex containing groups of sclerenchyma, a dense wood, internal as well as external phloem, and a small pith. The roots, on the other hand, have no sclerenchyma in the cortex and no pith (Fig. 189).

Constituents.—Gelsemium contains three crystalline alkaloïds, gelsemine, gelsemicine, and sempervirine, and one amorphous one. The fluorescent compound scopoletin, resin, and fixed oil are also present. A powdered alcoholic extract of the drug is known as "gelsemin."

Uses.—Gelsemium appears to give good results in the treatment of neuralgia.

Family GENTIANACEÆ

The Gentianaceæ comprises 70 genera and about 800 species, most of which are annual or perennial herbs. In the larger of the two subfamilies, the Gentianoideæ, the leaves are opposite and decussate, the corolla lobes are contorted in the bud, and the axis shows bicollateral vascular bundles and interxylary phloem. The second subfamily, the Menyanthoideæ, consists of five genera of aquatic or semi-aquatic plants. It is represented in Britain by the buckbean, *Menyanthes trifoliata*. Bitter principles are commonly found in the members of the Gentianaceæ, e.g. in the official gentian root, in the herb Indian gentian (*Swertia Chirata*), and in the buckbean.

GENTIANÆ RADIX

Gentiana, B.P. ; *Gentian Root*, *Yellow Gentian Root* ; F. *Racine de Gentiane* ; G. *Enzianwurzel*, *Bitterwurzel*

Source.—Gentian consists of the dried rhizomes and roots of the yellow gentian, *Gentiana lutea*, a perennial herb about 1 metre high found in the mountainous districts of Central and Southern Europe and Asia Minor. Important districts for its collection are the Pyrenees, the Jura and Vosges Mountains, the Black Forest, Bosnia, and the Carpathians.

Collection and Preparation.—When the plants are from two to five years old the turf is carefully stripped around each and the rhizomes and roots dug up. This usually takes place from May to October, collection in the autumn being more difficult on account of the hardness of the soil although possibly preferable from the medicinal point of view. There is little demand for “white” or unfermented gentian, which is prepared by drying the drug immediately after removal from the ground, most of the commercial drug consisting of “red” or

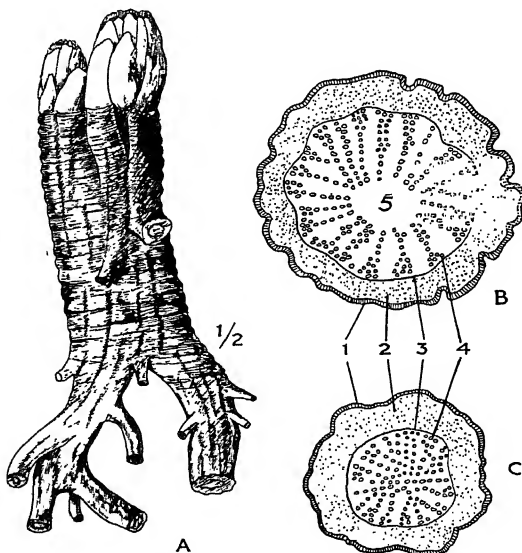


FIG. 190.—A, Gentian rootstock and roots; B, transverse section of rootstock; C, transverse section of root. 1, cork; 2, bark; 3, cambium; 4, wood; 5, pith. (All after Gilg.)

fermented gentian. The method of preparing this varies somewhat in different districts. Usually the drug is made into heaps, which are allowed to lie on the hillside for some time and may even be covered with earth. After washing and cutting into suitable lengths the drug is dried, first in the open air and then in sheds. Prepared in this way the drug becomes much darker in colour, loses some of its bitterness, and acquires a very distinctive odour. The unfermented root is now almost unknown in Britain.

History.—Gentian, possibly not derived from the species now official, was known to Dioscorides and Pliny. The drug was commonly employed during the Middle Ages.

Macroscopical Characters.—The plant has a cylindrical rhizome which may attain a diameter of 4 cm. and give off roots more than a metre in length. The crown bears from one to four aerial stems. The fresh root is whitish and fleshy internally, and practically odourless.

The commercial drug consists of simple or branched, cylindrical pieces up to 10 or 20 cm. in length and 1 to 3 cm. in diameter. The outer surface is covered with a yellowish-brown cork. The rhizomes are usually of larger diameter than

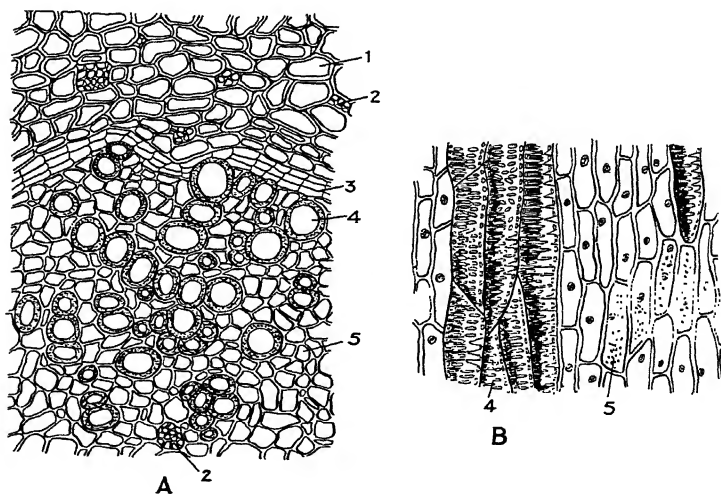


FIG. 191.—Gentian root. A, transverse section; B, longitudinal section. 1, parenchyma of bark; 2, phloem; 3, cambium; 4, vessel; 5, wood parenchyma containing calcium oxalate. (A after Gilg, B after Vogl.)

the roots and frequently bear one or more apical buds and encircling leaf scars. On drying, the rhizomes wrinkle transversely, whereas the roots wrinkle longitudinally. The drug is brittle when perfectly dry, but readily absorbs moisture from the air and becomes very tough. It has a pleasant, characteristic odour and a sweet taste, which later becomes bitter.

Microscopical Characters.—A transverse section shows an orange-brown bark separated by a darker cambium line from the porous, very indistinctly radiate wood. Only the rhizomes show a pith.

More detailed examination shows about four to six rows of thin-walled cork cells between which and the cambium is a somewhat thick-walled phelloderm and a wide zone of brown, thin-walled parenchyma containing oil globules and minute needles of calcium oxalate. Small groups of soft bast are seen in the phloem ring, but bast fibres are absent.

Examination of the wood and pith shows abundant parenchyma having similar cell-contents to that of the bark. The vessels have reticulate or scalariform thickening. Islands of soft bast occur in the wood. The drug contains very little starch and no sclerenchymatous cells or fibres. For powder, see p. 110.

Constituents.—Gentian contains bitter glycosides (and their products of hydrolysis), sugars, a yellow crystalline acid (gentisic or gentianic acid), oily matter, pectin, calcium oxalate, and a little starch.

According to Tanret (1905), the fresh drug contains the crystalline glycosides, gentiopicroin and gentiin, and the amorphous glycoside, gentiamarin. During the slow drying process (and according to Brindel (1920) also on the storage of unfermented root), the gentiopicroin disappears. The hexatriose, gentianose, and the sucrose originally present are also more or less completely hydrolysed during the fermentation. The products of the complete hydrolysis of these glycosides and sugars are indicated below :—

Gentiopicroin	→	Gentiogenin + Glucose
Gentiin	→	Gentienin + Glucose + Xylose
Gentiamarin	→	An amorphous substance + Glucose
Gentianose	→	Gentiobiose + Fructose
		↓
		2 Glucose
Sucrose	→	Glucose + Fructose

If fermentation is allowed to proceed too far, the hexose sugars are converted into alcohol and carbon dioxide. When carefully prepared gentian yields about 40 per cent. of water-soluble extractive (official minimum 33 per cent.), but highly fermented root yields much less.

Allied Drugs.—The roots of other species of *Gentiana*; e.g.

G. purpurea, *G. pannonica*, and *G. punctata*, have been imported. They appear to have similar medicinal properties to the official drug but are usually of smaller size.

Adulterants.—Adulteration, probably owing to careless collection, sometimes occurs. The rhizomes of *Rumex alpinus*, which give the test for anthraquinone derivatives, have been reported; also a dangerous but easily detected admixture with the rhizomes of *Veratrum album*.

Uses.—Gentian is used as a bitter tonic.

Family APOCYNACEÆ

The Apocynaceæ comprises 155 genera and about 1,000 species, most of which are woody climbers found, in the tropics and sub-tropics. The only British species are *Vinca major* (Larger Periwinkle) and *V. minor* (Lesser Periwinkle). The tropical species, *Vinca rosea*, which is often cultivated in this country, contains alkaloids.* Alkaloids are also found in the barks of *Alstonia scholaris* and *A. constricta*, which were formerly official.

STROPHANTHI SEMINA

Strophanthus, B.P.; *Strophanthus* Seeds; F. *Strophanthus*;
G. *Strophanthussamen*

Source.—The official drug consists of the dried ripe seeds of *Strophanthus kombé*, freed from the awns. *S. kombé* is one of about thirty species of *Strophanthus* found in Africa, where it occurs in the neighbourhood of the East African lakes (Nyanza, Tanganyika, and Nyassa) and the Shiré River. The seeds are exported from Zomba in Nyassaland and the ports of Portuguese East Africa (Quilimane, Inhambane, and Chinde).

History.—Seeds derived from species of *Strophanthus* have long been used by the natives of East and West Africa for the preparation of arrow-poisons. One of these, known to the natives of the Shiré River as *kombi*, was noted by Livingstone in 1861. Specimens of both the extract and the seeds were sent to England and in 1885 Fraser isolated strophanthin and recommended the use of the seeds in medicine.

* Cowley and Bennett, *Australasian J. Pharm.*, 1928, 9, 61.

Collection and Preparation.—The plant is a liane which occurs both wild and cultivated. Each flower gives rise to two divergent follicles which, when ripe, are 20 to 35 cm. long and 2 to 2.5 cm. broad. If the fruits are exported, which is rarely the case, the epicarp and mesocarp are first scraped off leaving a leathery endocarp surrounding the seeds. Each follicle contains a large number of seeds which are furnished with feathery awns (Fig. 192, D). The latter is almost invariably removed from the seed before exportation.

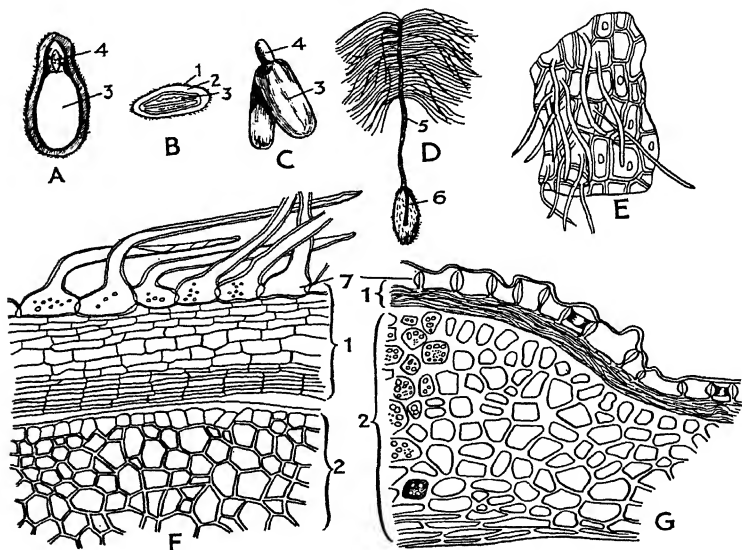


FIG. 192.—*Strophanthus kombé*. A, seed in longitudinal section; B, the same in transverse section; C, isolated embryo; D, seed with feathery awn; E, surface view of seed; F, radial longitudinal section of the seed coat and endosperm. 1, testa; 2, endosperm; 3, cotyledon; 4, radicle; 5, awn; 6, raphe; 7, lignified walls of epidermal cells and hairs. (After Tschirch-Oesterle, *Atlas*.)

Macroscopical Characters.—The seeds of *Strophanthus kombé* are lanceolate or linear-lanceolate in shape, somewhat flattened, 12 to 18 mm. long, 3 to 5 mm. broad, and 0.5 to 2 mm. thick. The testa is densely covered with greyish-green or fawn silky hairs, which are directed towards the acuminate apex. On the ventral surface a small ridge, the raphe, runs from a point

near the centre of the seed to its apex, where the point of attachment of the awn may be seen.

With care the embryo may be removed from the seed. It consists of two large, plano-convex cotyledons and a small radicle (Fig. 192, C). Transverse and longitudinal sections of the seed show that the embryo is surrounded by a narrow endosperm. If one of these sections be mounted in cold 80 per cent. sulphuric acid and examined under the low power of a microscope, characteristic colour changes will be observed in the endosperm and cotyledons. These colour changes, which are of great diagnostic importance, are described by Mathiesen as follows : * "Yellow, yellow-green, emerald-green, Russian green; in the embryo a more violet tint; dull blue-green, violet." The seeds have a slight odour and a very bitter taste.

Microscopical Characters.—If the seed coat be removed and mounted with the outer surface uppermost (Fig. 192, E), the regularly arranged hairs with thickened bases may be noted. If the inner epidermis of the testa be mounted uppermost scattered cluster crystals and occasional single crystals of calcium oxalate will be seen.

From the arrangement of the hairs it will be apparent that longitudinal sections will differ in appearance from transverse ones. These sections are shown in Fig. 192, F and G. The lignified hairs recall those of *nux vomica*. Each has a band-shaped thickening at its base. The cells of the endosperm and embryo are rich in oil and protein and give the sulphuric acid colour reactions characteristic of *k*-strophanthin. For powder, see p. 105.

Allied Drugs.—While the British Pharmacopœia admits only the seeds of *Strophanthus kombé*, those of two other species, namely, *S. hispidus* and *S. gratus*, are official in a number of foreign pharmacopœias. The seeds of *S. Courmonti* have been studied with a view to their possible inclusion in the British Pharmacopœia.† The seeds of these and other species may be distinguished by the following characters :—

* Mathiesen, *Pharm. Act. Helv.*, 1927, 2, 228, and 1928, 3, 21, 34; quotation as abstracted in *Y. B. Pharm.*, 1928, 260, 262.

† A Report on Work Done for the B.P. Commission on the Seeds of *S. Emini*, *Y. B. Pharm.*, 1935, 61–74, states : "The results now accumulated indicate that the seeds of this species of *strophanthus* are similar in their pharmacological action to those of *S. kombé*, that the tincture made from them presents no difficulties in biological assay, and that the mixture of glycosidal principles obtained from them is similar in chemical composition and in therapeutic effects to the *strophanthin* obtained from the seeds of *S. kombé*."

<i>Species.</i>	<i>Macroscopical Characters.</i>	<i>Trichomes.</i>	<i>Crystals.*</i>	<i>Colour Reaction with 75 per cent. v/v Sulphuric Acid.†</i>
<i>S. kombé</i>	Greyish-green to greenish-fawn; lanceolate to linear-lanceolate; flatter and with more marked raphe than <i>Courmonti</i> .	Abundant.	A few clusters and often also small single crystals in testa.	Dark green.
<i>S. Courmonti</i>	Greyish-green to brown; broadly lanceolate; raphe less marked than in <i>kombé</i> .	Abundant.	Abundant single and twin crystals and occasional cluster and conglomerate ones in seed coat.	Brown; green at edges in 10 minutes.
<i>S. Nicholsoni</i>	Whitish-brown; broadly lanceolate.	Very thick woolly covering.	Absent.	Brown; violet in 10 minutes.
<i>S. gratus</i>	Brown; compressed and somewhat twisted; margin sharp-angled and almost winged.	Small papillæ; appear glabrous.	Absent.	Pale orange-pink.
<i>S. Emini</i> ...	Brownish-yellow; lanceolate; raphe less marked than <i>kombé</i> .	Abundant, golden-yellow.	Absent.	Brown; violet in 5 minutes.
<i>S. sarmentosus</i>	Reddish-brown to greenish; apex shows a well-marked twist.	Abundant, fragile and often rubbed off.	Abundant single and twin crystals and some clusters and conglomerates in seed coat; <i>clusters in cotyledons</i> .	Pale pink in 5 minutes.
<i>S. hispidus</i> ...	Brownish; almost spindle-shaped.	Abundant, silky and often rubbed off.	Few clusters in seed coat.	Brownish-red.

Constituents.—*Strophanthus* contains about 8 to 10 per cent. of a mixture of glycosides known as strophanthin or *k*-strophanthin. The drug also contains about 30 per cent. of fixed oil, the alkaloids trigonelline and choline, resin and mucilage.

Strophanthin is soluble in water and in dilute alcohol, but sparingly soluble in most organic solvents. The seeds may, therefore, be defatted with a solvent such as light petroleum without extracting the glycosides. The latter are then extracted by means of alcohol, freed from inert material, and finally obtained in crystals by the concentration, *in vacuo*, of a solution of them in dilute alcohol.

* Details of macroscopical characters, trichomes and crystals from paper by Mathiesen abstracted in *Y.B. Pharm.*, 1928, 260, 262, which may be consulted for further details.

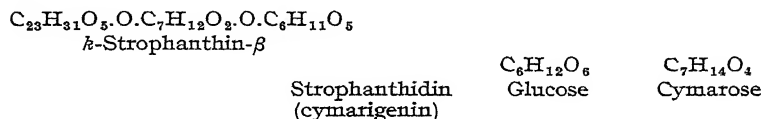
† See Smelt, *Y.B. Pharm.*, 1933, 467-474. According to Smelt the test is best done on tinctures evaporated to dryness, and 75 per cent v/v acid gives more distinct colours than 65 per cent.

Strophanthin is standardised by biological assay. As a standard ouabain or *g*-strophanthin, the crystalline glycoside of *S. gratus*, is used. This is a single compound of the formula $C_{29}H_{44}O_{12}$ and not a mixture of glycosides as is *k*-strophanthin.

k-Strophanthin is a mixture of the glycosides * amorphous *k*-strophanthin, *k*-strophanthin- β and cymarine. The latter glycoside also occurs in the root of *Apocynum cannabinum* (Canadian hemp). These glycosides can be hydrolysed as follows :—

Amorphous *k*-strophanthin \longrightarrow Strophanthidin + Glucose + Cymarose
k-strophanthin- β \longrightarrow Cymarine + Glucose
 Cymarine \longrightarrow Strophanthidin + Cymarose

The complete reaction for *k*-strophanthin- β may be written :—



Uses.—Strophanthus resembles digitalis in its action and in certain cases is preferable. Strophanthin is official in the British Pharmacopœia and the U.S.P. XI.

Order CONVOLVULALES

The Convolvulales is closely allied to the next order, the Tubifloræ, but is distinguished from it by the presence of latex and the placentation of the ovules.

Family CONVOLVULACEÆ

The Convolvulaceæ comprises 47 genera and about 1,100 species, of which about 400 belong to the genus *Ipomœa* and 200 to *Convolvulus*. The family includes annual and perennial herbs, many having twining stems, and some shrubs. Among the anatomical features may be mentioned the presence of latex cells, bicollateral vascular bundles and the frequent occurrence of abnormal vascular structures such as are described below under jalap.

* For further details, see Stoll, *The Cardiac Glycosides*, 1937.

JALAPÆ TUBER

Jalapa, B.P., *Jalapæ Radix*; *Jalap*; F. *Racine de Jalap*;
G. *Jalapenknollen*

Source.—Jalap consists of the dried tubercles or tuberous roots of *Ipomœa purga* Hayne (*Exogonium purga* Benth.), a large, twining plant indigenous to Mexico. The plant is cultivated in India, Jamaica, and South America, but most of the drug is imported from Eastern Mexico under the name of "Mexican" or "Vera Cruz" jalap.

Collection and Preparation.—The underground portion of the plant consists of thin horizontal runners, from the nodes of which adventitious roots arise. Some of the latter remain thin, but others fill with starch and swell enormously to form the tubercles used in medicine. They are collected throughout the year but more particularly in May, after the rains. The tubercles are sometimes dried in the sun, an operation taking about a month, but more usually in nets over wood fires in the collectors' huts. Slits are sometimes made in the tubercles, which are potato-like in texture when fresh,* to allow the moisture to escape. Jalap is exported in sacks holding about 100 to 200 lb.

History.—Convolvulaceous tubers with purgative properties were brought to Spain about 1565 when they were mentioned by Monardes. According to the *Pharmacographia*, it is doubtful if this was the jalap of modern commerce.

Macroscopical Characters.—Jalap tubercles (Fig. 193, A) are fusiform, napiform, or irregularly oblong in shape and from 3 to 15 cm. long. They are extremely hard and heavy.† The surface is covered with a dark brown, wrinkled cork, which is marked with lighter coloured, transverse lenticels. The larger pieces may bear gashes, which have been made to facilitate drying. The tubercles may be softened for cutting by prolonged soaking in water. Cut transversely they show a greyish interior, a complete cambium ring fairly close to the outside and within it numerous irregular dark lines (see p. 562).

* The tubercles of an allied species, *Ipomœa Batatas*, are known as "sweet potatoes" and form an important food in the tropics and subtropics. Their starch forms Brazilian arrowroot.

† The drug is often called *jalap lourd* in France, while the root of *I. orizabensis* is known as *jalap léger*. The latter drug is often referred to as light jalap in this country.

The drug has a slight, smoky odour; the taste is at first sweetish, afterwards acrid.

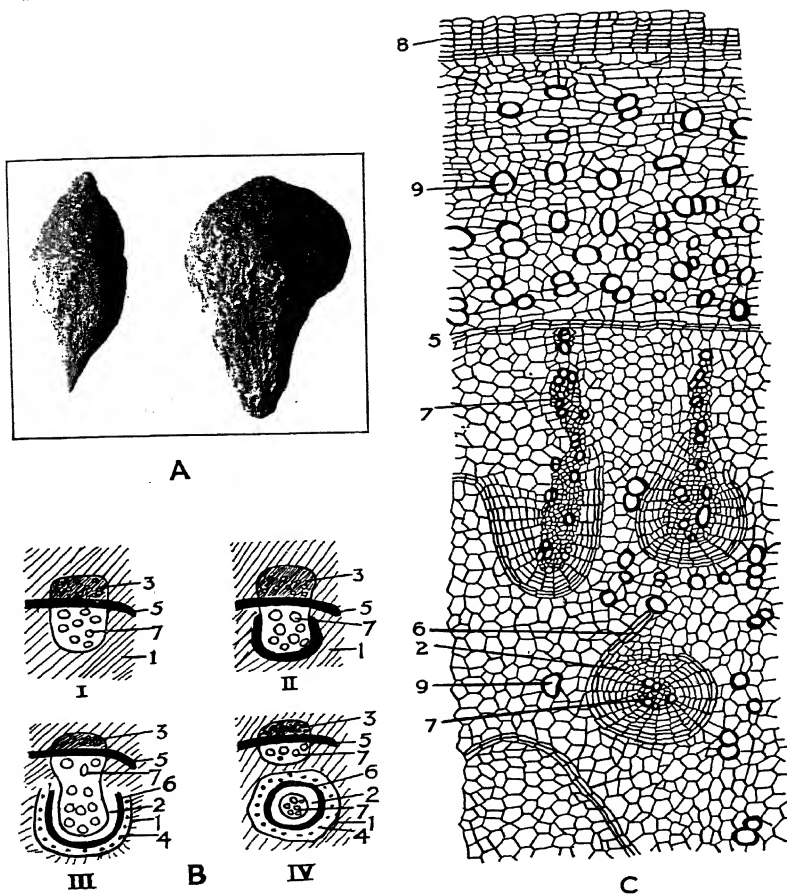


FIG. 193.—Jalap. A, whole tubers; B, diagram showing the formation of the abnormal bundles; C, a transverse section. 1, parenchyma; 2, new parenchyma; 3, normal phloem; 4, new phloem; 5, cambium; 6, new cambium; 7, wood; 8, cork; 9, secretion cell. (B after Planchon, C after Tschirch.)

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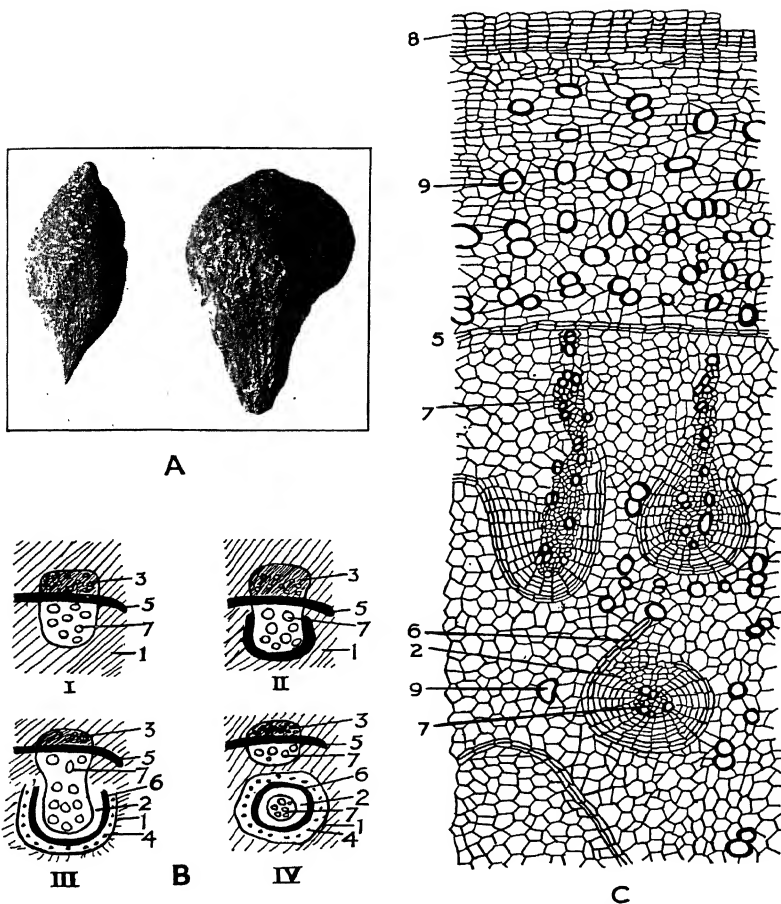


FIG. 193.—Jalap. A, whole tubers; B, diagram showing the formation of the abnormal bundles; C, a transverse section. 1, parenchyma; 2, new parenchyma; 3, normal phloem; 4, new phloem; 5, cambium; 6, new cambium; 7, wood; 8, cork; 9, secretion cell. (B after Planchon, C after Tschirch.)

Microscopical Characters.—A transverse section (Fig. 193, C) shows that the bark consists of brownish, thin-walled cork cells and a cortex and phloem in which are numerous secretion cells. The bark is separated from the stele by a brown cambium line on the inner side of which are radial strips of primary wood separated by broad medullary rays. Within these are numerous concentric vascular bundles which are formed by secondary meristems as indicated in Fig. 193, B. When fully formed these have a central wood and external phloem separated by a circular cambium. Secretion cells, whose contents stain yellow with iodine water, are scattered throughout the section. The parenchyma contains single, rounded, or ovoid starch grains from 5 to 65μ in diameter and compound grains with two to six components; also cluster crystals of calcium oxalate about 10 to 35μ in diameter. The starch grains are often partly gelatinised. In longitudinal section or in powder the vessels are seen to have numerous bordered pits. For powder, see p. 109.

Constituents.—Jalap contains from 4 to 20 per cent. (official minimum 9 per cent.) of resin, which may be extracted from the powdered drug with boiling alcohol (90 per cent.). On pouring a concentrated tincture into water the resin is precipitated and may be collected, washed, and dried. The drug also contains mannite, sugars, calcium oxalate, starch, and a fluorescent substance, scopoletin (p. 677).

Jalap resin is a very complex mixture. About 10 per cent., known as "scammonin," is soluble in ether and contains a small amount of ipurganol, $C_{21}H_{32}O_2(OH)_2$, which gives the colour reactions of a phytosterol. The larger, ether-insoluble portion is called "jalapin." The resin appears to be partly glycosidal in nature since glucose is found after its hydrolysis together with convolvulinic acid, $C_{15}H_{30}O_3$, formic acid, butyric acid, and α -methylbutyric acid.

Allied Drug.—*Tampico jalap*, which consists of the dried tubercles of *Ipomœa simulans*, is occasionally found in commerce. The surface is convoluted and lacks the distinct lenticels of the official drug. The resin (tampicin) which it contains differs from that of jalap in being completely soluble in ether.

Uses.—Jalap is a powerful hydragogue cathartic.

IPOMCEÆ RADIX

Ipomœa, B.P.; *Ipomœa*, Orizaba Jalap, Mexican Scammony Root, Light Jalap; *F. Jalap fusiforme*, mâle ou léger; *G. Orizabajalap*

Source.—*Ipomœa* is the dried root of *Ipomœa orizabensis*, a convolvulaceous twining plant with a fusiform root about 60 cm. long. The drug is collected in the Mexican state of Orizaba and is exported from Vera Cruz.

History.—Orizaba was originally imported as a substitute or adulterant of jalap or its resin ("jalapin"). The resin is, however, more soluble in ether than jalap resin and more closely resembles that obtained from the root of *Convolvulus Scammonia*, which was the original source of scammony resin. On account of the increasing scarcity of the latter drug, the 1914 Pharmacopœia permitted the resin of either *C. Scammonia* or *I. orizabensis* to be used as scammony resin. Scammony resin of the 1932 Pharmacopœia is obtained solely from *I. orizabensis*.

Characters.—Whole roots of *ipomœa* are rarely imported and the drug usually consists of transverse or oblique slices about 3 to 5 cm. wide and 2 to 4 cm. thick. Large roots are sometimes cut longitudinally as well as transversely but, possibly owing to the collection of smaller roots, the rectangular pieces obtained by "quartering" the root appear to be less common than was formerly the case.*

The outer surface is covered with a greyish-brown, wrinkled cork. The transverse surface is greyish or brownish and shows a number of concentric rings of fibrovascular bundles. The parenchymatous tissue of both bark and stele resembles that of jalap in containing starch and calcium oxalate. Like jalap, the section shows numerous scattered secretion cells with resinous contents. The drug has a slight odour and a faintly acrid taste.

Constituents.—*Ipomœa*, when extracted with alcohol (90 per cent.), yields about 12 to 18 per cent. of a complex resinous mixture, of which about 65 per cent. is soluble in ether. To obtain comparative results with regard to different samples of the resin the method of determining the ether solubility must

* The *Pharmacographia*, p. 446, states "transverse slices are of rare occurrence," a statement which does not apply to the drug now in commerce.

be standardised or the results will be of little value. When the official method is followed the ether-insoluble matter in the resin should not exceed 40 per cent.

By successive treatment with different solvents orizaba resin yields: to petroleum spirit about 6 per cent. of fatty material, to ether about 65 per cent. of resin, and a further 25 per cent. of resin to ethyl acetate. The resins extracted by ether and ethyl acetate appear to be similar to one another and of glycosidal nature. On hydrolysis ipuranol, $C_{23}H_{38}O_2(OH)_2$, α -methylbutyric acid, tiglic acid, glucose, a methyl pentose, jalapinic acid, and methyl jalapinolate are produced. The drug also contains scopoletin, starch, and calcium oxalate.

Adulteration.—*Brazilian jalap*, the sliced roots of *Piptostegia Pisonis*, is sometimes imported. It occurs in similar sized slices to those of ipomœa and, like the latter, has concentric rings of wood. The fibres, however, do not project from the surface as much as in ipomœa. It contains about 20 per cent. of resin which, however, differs from the ipomœa resin in being very slightly soluble (only about 6 per cent.) in ether.

Uses.—Ipomœa is mainly used for the preparation of scammony resin. It resembles jalap in medicinal properties.

Allied Drugs.—Scammony Root is the dried root of *Convolvulus Scammonia*, a large twining plant found in the Balkans, Asia Minor, Caucasus Mountains, Syria, and Iraq. It was formerly exported from the Black Sea ports (Batoum, Odessa), but is now of small commercial importance. Typical pieces of drug measure about 2 to 5 cm. in diameter and from 10 to 20 cm. in length. The roots are greyish-brown, almost cylindrical and spirally furrowed. They have an enlarged crown bearing the remains of aerial stems. The internal structure recalls that of jalap but is more fibrous, and the bark is thinner and less well defined.

Scammony root contains about 3 to 13 per cent. of resin, which is almost entirely soluble in ether. This resin is not identical with orizaba resin but closely resembles it in chemical nature and in physiological action.

Scammonium or Scammony Gum-Resin is obtained from the living root of *C. Scammonia* by cutting off its crown and collecting the exudation in mussel shells. The dried secretion consists of resin, similar to that obtained from the dry root, and gum. The drug is very expensive, appears to be in no way superior to other convolvulaceous resins, and is now

rarely used. It usually occurs in small, brownish cakes having a somewhat cheesy odour. If not dried immediately after collection a certain amount of fermentation takes place and the drug becomes more porous. It is very liable to adulteration. Being a gum-resin it forms an emulsion when triturated with water. If of good quality, it yields about 70 to 80 per cent. of ether-soluble resin.

Other convolvulaceous drugs which are sometimes employed for their purgative action are *turpeth*, the dried root and stem of *Ipomœa Turpethum*, and *kaladana*, the dried seeds of *Ipomœa hederacea*. These drugs, although seldom prescribed in Britain, are used in India.

Order TUBIFLORÆ

The Tubifloræ is a large order which is subdivided into four suborders and seventeen families. Of medicinal interest are:—

- Suborder **Boraginineæ**, Family Boraginaceæ and Hydrophyllaceæ.
- „ **Verbenineæ**, Family Labiateæ.
- „ **Solanineæ**, Families Solanaceæ, Scrophulariaceæ, and Pedaliaceæ.

The members of the above families are usually herbs with alternate or opposite, simple leaves. The flowers are generally bisexual and often zygomorphic. They usually have two or four, epipetalous stamens and a bicarpellary, superior ovary.

Of the families mentioned above the Pedaliaceæ and Boraginaceæ may be dismissed with a brief reference to sesame oil and alkanet root.

Oleum Sesami.—Sesame oil is a fixed oil obtained by expression from the seeds of *Sesamum indicum* (Fam. Pedaliaceæ), a herb which is widely cultivated in India, China and Japan. The oil, of which the seeds yield about 50 per cent., is officially permitted to be used under certain circumstances instead of olive oil. Sesame oil may be detected by the production of a pink colour when it is shaken with half its volume of hydrochloric acid containing 1 per cent. of sucrose (Baudouin's Test).

Anchusæ Radix.—*Alkanna* or *Alkanet Root*.—*Alkanna* is the dried root of *Alkanna tinctoria* (Fam. Boraginaceæ), a herb found in Hungary, Southern Europe and Turkey. The

drug consists of reddish-purple roots about 10 to 15 cm. long and 1 to 2 cm. in diameter near the crown. The surface is deeply fissured and readily exfoliates. Attached to the crown are the remains of leaves having whitish, bristly hairs. Alkanna contains the red colouring matters, alkannic and anchusic acids. It is used for colouring oils and fats and, in the form of a tincture, for the microscopical detection of oils and fats.

Family **HYDROPHYLLACEÆ**

A family of about 170 species, mostly North American. Herbs commonly hairy, with mostly alternate leaves. Flowers chiefly blue or white, in one-sided cymes or false racemes which are mostly bractless, and coiled from the apex when young.

ERIODICTYI FOLIA

Eriodictyon U.S.P., Yerba Santa, Consumptive's Weed, Bear's Weed, Mountain Balm; F. *Fewilles d'Eriodictyon*; G. *Eriodictyon*.

Source.—*Eriodictyon* consists of the dried leaf of *Eriodictyon californicum*, a low evergreen shrub of the hills and mountains of California and northern Mexico.

Macroscopic Characters.—The leaves usually occur in fragments; when entire, they are lanceolate, from 5 to 15 cm. long, and from 1 to 3 cm. wide. The apex is acute; the base slightly tapering into a short petiole. The margin is irregularly serrate or crenate-dentate. The upper surface is yellowish-brown to greenish-brown and covered with a glistening resin. The lower surface is greenish-gray to yellowish-gray, conspicuously reticulate with greenish-yellow or brown veins, and minutely tomentose (cottony) between the reticulations. The leaves are thick and brittle. They have an aromatic odour, and a balsamic bitter taste, which becomes sweetish and slightly acid.

Microscopic Characters.—Characteristic elements are unicellular non-glandular hairs which are undulate and have thick walls; glandular hairs with one-celled stalks, and six- to eight-celled heads, the latter being up to 75μ in diameter; tracheæ with spiral thickenings or simple pores, and associated with lignified fibres. Starch grains are few, from 3μ to 20μ in diameter. Calcium oxalate crystals are abundant, in rosette aggregates, from 5μ to 30μ in diameter.

Constituents.—Eriodictyon contains volatile oil, resin, eriodictyol, homoeriodictyol, chrysoeriodictyol, xanthoeriodictyol, eriodonol, eriodictyonic acid, and ericolin.

Uses.—Yerba Santa is used in coughs, colds, asthma, and in inflammations of the uro-genital organs. It is also used pharmaceutically as a vehicle for masking the taste of bitter and otherwise disagreeable medicines, particularly quinine.

Family LABIATÆ

The Labiatae consists of 170 genera and about 3,000 species, most of which are aromatic annual or perennial herbs. The family is well represented in Britain and in the Mediterranean countries. The Labiatae have bisexual, zygomorphic flowers, which are usually of the floral formula $K(5), C(5), A_4, G(2)$, and are arranged in verticillasters. The corolla is bilabiate and the stamens are didynamous. Occasionally the number of stamens is reduced to two, *e.g.* in *Rosmarinus*. The ovary becomes four-celled and has a single ovule in each loculus. With the exception of *Rosmarinus* the medicinally important species have a gynobasic style, and the four nutlets have only a small surface of contact with one another.

The herbaceous members of the family have square stems. The leaves and other aerial parts have clothing hairs and characteristic glandular hairs (see Fig. 41, L), which secrete oil. The stomata are of the type shown in Fig. 42, B.

Numerous labiate plants are used as culinary herbs or for the preparation of volatile oils. In addition to rosemary, lavender, and peppermint, which are described below, the following may be mentioned: spearmint (*Mentha spicata*), pennyroyal (*Mentha pulegium*), sweet marjoram (*Origanum majorana*), patchouli (*Pogostemon patchouli*), melissa (*Melissa officinalis*), sage (*Salvia officinalis*), and hyssop (*Hyssopus officinalis*). Also thyme (*Thymus vulgaris*) and *Monarda punctata*, both of which are important sources of thymol.

HERBA ET OLEUM ROSMARINI

Rosemary and Oil of Rosemary; F. *Rosmarin et Essence de Rosmarin*; G. *Rosmarin und Rosmarinöl*

Source.—Oil of rosemary, which is official in the British Pharmacopœia, is a volatile oil distilled from the flowering plant, *Rosmarinus officinalis* Linn. Rosemary is a native of

Southern Europe and the oil is produced in the South of France, the Dalmatian Islands, Spain, and North Africa. The plant has long been cultivated in England, probably prior to the Norman Conquest, but not on a commercial scale.

Characters.—Rosemary is an evergreen shrub which attains a height of 1 to 2 metres and has slender, ash-coloured branches. The leaves are about 3·5 cm. long, 2 to 4 mm. broad, rigid, opposite, sessile, and linear. The upper surface is dark green and glossy, while the lower surface is grey and woolly owing to the presence of numerous branched hairs. Typical labiate, glandular hairs are also present. The margins of the leaf are revolute, and the midrib is very prominent on the lower surface.

Rosemary bears verticillasters of mauve flowers which in England appear from April to June. The flowers are easier to examine than those of lavender or the mints on account of their larger size. They have a campanulate, two-lipped calyx and a widely-gaping, two-lipped corolla. The upper lip of the corolla has two lobes and the lower lip three. Only the anterior pair of stamens develop. The bicarpellary ovary develops into four nutlets.

Constituents.—Rosemary yields about 1 to 2 per cent. of volatile oil. This oil contains 0·8 to 6 per cent. of esters (calculated as bornyl acetate) and 8 to 20 per cent. of total alcohols (calculated as borneol, $C_{10}H_{18}O$). The official oil is required to contain not less than 2 per cent. of esters and not less than 9 per cent. of *free* alcohols.

HERBA ET OLEUM LAVANDULÆ

Lavender and Oil of Lavender ; F. Lavande et Essence de Lavande ; G. Lavendel und Lavendelöl

Source.—Oil of lavender, which is official in the British Pharmacopœia, is a volatile oil distilled from the fresh flowering tops of *Lavandula officinalis* Chaix. Lavender is a native of Southern Europe, where it is widely grown. The English-grown herb yields an oil which is more esteemed than the Continental and differs markedly from it in chemical composition.

Continental oils differ among themselves owing to the fact that a number of different species, varieties, and hybrids are

distilled. The true lavender, *Lavandula officinalis*, yields the best oil when grown at a fairly high altitude, the variety growing under these conditions being known as "petite lavande." At a lower altitude the "lavande moyenne" yields a somewhat less esteemed oil. "Grande lavande," *Lavandula latifolia* Villers (*L. spica* DC.*), yields a much coarser oil, which is sold as oil of spike. The above plant readily hybridises with *Lavandula officinalis*, yielding a plant known as "gross lavande" or "lavandin," the oil of which is intermediate in character between that of the parent forms. Lavandin is said to be grown on a large scale.†

Characters.—Lavender is an evergreen shrub which attains under cultivation a height of about 1 metre.‡ The leaves are oblanceolate-linear in shape and have entire, revolute margins. The upper branches are distinctly square and bear terminal spikes of six to ten verticillasters, each whorl having from six to ten flowers.

The plant flowers from July to September. The flowers are much smaller than those of rosemary. Each arises in the axil of a rhomboidal bract (*L. latifolia* has linear bracts). The calyx is five-toothed (the posterior one being much larger than the others) and has thirteen ribs. It is bluish-violet in colour, very hairy, and shows shining oil glands. The corolla is purplish-grey, tubular, and two-lipped, the posterior lip having two lobes and the anterior one three lobes. The four stamens are inserted on the hairy throat of the corolla. The fruit is of the usual labiate type. If transverse sections of the calyx or corolla are examined both will show multicellular, branched, clothing hairs and labiate glandular hairs containing volatile oil.

Constituents.—The fresh flowering spikes yield about 0.5 per cent. of volatile oil. The amount varies according to variety, season, and method of distillation, modern steam stills giving a rather larger yield than those in which the flowers are boiled with water.

English oil commands the highest price. It contains about 7 to 14 per cent. of esters (chiefly linalyl acetate), linalol, geraniol, cineole, limonene, and a sesquiterpene. Genuine Continental lavender oil normally contains over 35 per cent.

* Note, *Lavandula spica* DC. = *L. latifolia* Vill., but *L. spica* Linn. = *L. officinalis* Choix.

† For further details, see Parry's *Chemistry of Essential Oils*.

‡ In the wild state *L. officinalis* is about half a metre high and *L. latifolia* about 1 metre high.

of esters. Oil of spike, which is largely used in cheap perfumery, contains little ester but a high proportion of free alcohols (about 23 to 41 per cent. calculated as borneol). Hybrids are of intermediate character, *e.g.* "lavandin oil" containing about 6 to 9 per cent. of esters and about 35 per cent. of alcohols. The nature of the alcohols also varies from a mixture of linalol and geraniol in the best lavender oil to borneol in the oil of spike. Sufficeint has been said to indicate some of the variations to be expected in the analysis of *Lavandula* oils, and works on essential oils may be consulted for more detailed information.

HERBA ET OLEUM MENTHÆ PIPERITÆ

Peppermint and Oil of Peppermint; F. *Menthe Poivrée et Essence de Menthe Poivrée*; G. *Pfefferminze und Pfefferminzeöl*

Source.—Oil of peppermint is officially described as "the oil distilled from the fresh flowering tops of *Mentha piperita* Linn., and rectified, if necessary." The European and American oil appears to be derived to a large extent from the



FIG. 194.—Carting peppermint, Long Melford (Stafford Allen & Sons, Ltd.).

two varieties * *M. piperita*, var. *vulgaris* Sole ("black mint"), and *M. piperita*, var. *officinalis* Sole ("white mint"). Japanese peppermint oil is derived from *M. canadensis*, var. *piperascens*.

Characters.—All the mints have square stems and creeping rhizomes. The flowers are arranged in verticillasters and have the floral formula K(5), (C5), A₄, G(2). The black mint, which is the one most commonly cultivated in England, has purple stems and dark green petiolate leaves which are tinged with purple. The leaves are 3 to 8 cm. long and have an acute apex and serrate margin. They are broader than those of *M. spicata* (spearmint), but narrower than those of *M. aquatica* (water mint). The small, purple flowers appear in the late summer.

Constituents.—The official oil of peppermint contains from 4 to 9 per cent. of esters calculated as menthyl acetate, and not less than 46 per cent. of free menthol. Some of the characters of commercial oils are indicated below and should be compared with the official requirements.

	American.	English Black Mint.	English White Mint.
Specific gravity	0.900 to 0.915	0.9036	0.9058
Optical rotation	−18° to −35°	−23.5°	−33°
Menthol, as esters	5 to 14 per cent.	3.7 per cent.	13.6 per cent.
Menthol, free	45 to 50 per cent.	59.4 per cent.	51.9 per cent.
Menthone ..	9 to 19 per cent.	11.3 per cent.	9.2 per cent.

Natural Japanese peppermint oil contains from 70 to 90 per cent. of menthol, for the extraction of which it is largely used. The dementholised Japanese oil of commerce contains approximately the same amount of menthol and its esters as the American oil.

Family SOLANACEÆ

The Solanaceæ comprises 85 genera and about 1,800 species. Of these only five species are indigenous to Britain, namely, *Datura Stramonium* (Thornapple), *Solanum dulcamara* (Bitter-

* As in the case of *Lavandula*, numerous *Mentha* hybrids and varieties are known. Light has recently been thrown on this subject by the study of genetics and it has been shown that peppermint, *M. piperita* Hudson, is *M. aquatica* Linn. × *M. spicata* L. et Hudson, all having the same chromosome number, namely, 18. This complex but interesting subject is fully dealt with in Tschirch's *Handbuch der Pharmakognosie*, 1932 edition, I, 2, 726–730.

sweet), *Solanum nigrum* (Black Nightshade), *Atropa Belladonna* (Deadly Nightshade), and *Hyoscyamus niger* (Henbane). Many tropical and sub-tropical species are, however, cultivated, e.g. *Solanum tuberosum* (Potato), *Solanum Lycopersicum* (Tomato), and *Nicotiana tabacum* (Tobacco).

The flowers are bisexual and seldom markedly zygomorphic, although the carpels are placed obliquely (see Fig. 160, D). They have the floral formula $K(5), C(5), A_5, G(2)$. The ovary is typically bilocular but frequently becomes falsely three- to five-locular, e.g. *Datura*.

On the flowering branches adnation of the leaves with their axillary branches often occurs and the true origin of the parts is only made out by cutting sections. In stramonium, for example, the leaf at any particular node really belongs to the node below (see Fig. 196, A), while in belladonna it gives rise to pairs of leaves of unequal sizes (see Fig. 199, A).

Stomata may be found on both surfaces of the leaf or on the lower surface only. Each stoma is surrounded by a variable number of subsidiary cells, but three or four of these, one being generally smaller than the others, is usual. Such stomata are commonly described as cruciferous or solanaceous. Both clothing and glandular hairs are found, the latter showing considerable variety both in the stalk and head. Crystal sand is of very common occurrence in the family, but solitary and cluster crystals are also found. All members of the family have intraxylary phloem which is often accompanied by sclerenchymatous fibres.

STRAMONII FOLIA

Stramonium, B.P. ; *Stramonium* or *Thornapple Leaves* ;
Jimson or *Jamestown Weed* ; F. *Feuilles de Stramoine* ;
 G. *Stechapfelblätter*

Source.—Stramonium consists of the dried leaves and flowering tops of *Datura Stramonium* and *D. tatula*. Stramonium probably originated in the Caspian region, but it is now almost as abundant in America as in the Old World. English supplies are derived partly from plants grown in this country but mainly from the Continent (Germany, France, Hungary, etc.).

Plant.—Stramonium is a bushy annual attaining a height of about 1.5 metres. The plant has a large, whitish root and

numerous rootlets. The erect aerial stem shows dichasial branching and the adnation referred to above. The stem and branches are round, smooth, and green. The flowers (Fig. 195) are solitary, axillary, and shortly stalked. They have a sweet scent. Each has a tubular, five-toothed calyx about 4.5 cm. long, a white, funnel-shaped corolla about 8 cm. long, five

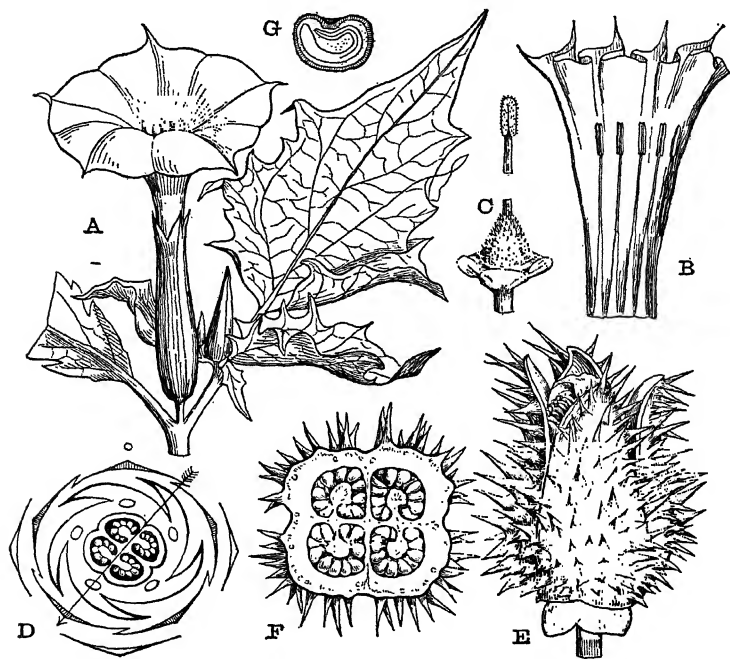


FIG. 195.—*Datura Stramonium*. A, end of flowering shoot; B, corolla cut open; C, pistil, the rest of the flower has been cut away; D, floral diagram, the arrow indicates the plane of symmetry; E, capsule opening; F, capsule in transverse section; G, seed in transverse section, showing curved embryo. All slightly reduced except G, which is enlarged. (From Rendle's *Classification of Flowering Plants*.)

stamens, and a bicarpellary ovary. The plant flowers in the summer and early autumn. The fruit is originally bilocular but as it matures a false septum arises, except near the apex, so that the mature fruit is almost completely four-celled. The ripe fruit is a thorny capsule about 3 to 4 cm. long.

D. tatula closely resembles the above but, possibly owing to the fact that its natural habitat is the tropics, it seldom reaches the size of our indigenous species when grown in England. The stems are reddish and the leaves have purplish veins as also have the lavender-coloured corollas.

History.—Stramonium was grown in England by Gerarde towards the end of the sixteenth century from seeds obtained from Constantinople. The use of the drug is largely due to the experiments of Störck (1762).

The generic name, *Datura*, is derived from the name of the poison, *dhât*, which is prepared from Indian species and used by the Thugs.

Macroscopical Characters.—Fresh stramonium leaves or herbarium specimens should first be examined since the commercial leaves are much shrunk and twisted, and their shape can only be ascertained by careful manipulation after soaking them in water. A portion of the leaf should be cleared by boiling in chloral hydrate solution and examined for calcium oxalate.

The dried leaves are greyish-green in colour, thin, brittle, twisted, and often broken. Whole leaves (Fig. 195, A) are 8 to 25 cm. long and 7 to 20 cm. wide, those of *D. Stramonium* being somewhat larger than those of *D. tatula*. Both kinds of leaf are shortly petiolate, ovate, or triangular-ovate in shape, acuminate at the apex and have a sinuate-dentate margin. They are distinguished from the leaves of the Indian species, *D. innoxia*, *D. metel*, and *D. fastuosa*, by the margin, which possesses teeth dividing the sinuses, and by the lateral veins which run into the marginal teeth.

The commercial drug contains occasional flowers and young capsules, which have been described above. Also, the smaller stems, which should not exceed 20 per cent. of the whole drug. Stramonium has a slight but unpleasant odour, and a bitter taste.

Microscopical Characters.—A transverse section of a leaf (Fig. 196, B) shows that it has a bifacial structure. Both surfaces are covered with a smooth cuticle and possess both stomata and hairs. Cluster crystals of calcium oxalate are abundant in the mesophyll, and microsphenoidal and prismatic crystals are also found. The stomata are of the usual solanaceous type and the epidermal cells have wavy walls. The clothing hairs are three- to five-celled, slightly curved, and have thin warty walls. The basal cell is usually

more than 50μ long (distinction from *D. metel*). Small glandular hairs with a one- or two-celled pedicel are also found. If portions of the leaf are cleared with chloral hydrate solution the abundance of the cluster crystals of calcium oxalate and their distribution with regard to the veins may be noted.

The midrib shows a bicollateral structure and characteristic subepidermal masses of collenchyma on both surfaces.

Stems are present, but few of these should exceed 4 mm. in

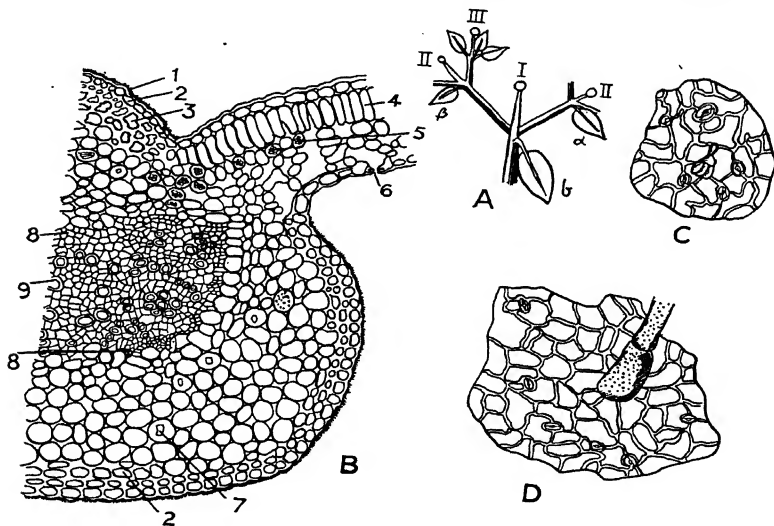


FIG. 196.—*Datura Stramonium*. A, plan of flowering branch; I, II, and III, successive shoots; *b*, bract of I; *α β* bracts of II, etc. B, transverse section of leaf. 1, cuticle; 2, epidermis; 3, collenchyma; 4, palisade cells; 5, rosette of calcium oxalate; 6, stoma; 7, prism of calcium oxalate; 8, phloem; 9, xylem. C, upper epidermis; D, lower epidermis. (After Tschirch-Oesterle, *Atlas*.)

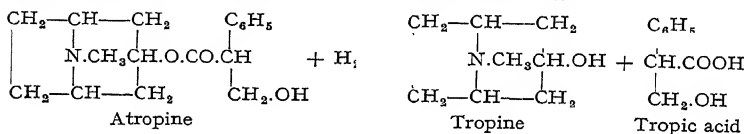
diameter. They possess epidermal hairs up to 800μ in length and have perimedullary phloem. The stem parenchyma contains calcium oxalate similar to that found in the leaf. For further details, see powder, p. 106.

Constituents.—*Stramonium* usually contains from 0.2 to 0.45 per cent. of alkaloids (official minimum 0.25 per cent.). The chief alkaloid present in both *D. Stramonium* and *D. tatula* is hyoscyamine, but a little atropine may be formed from the

hyoscyamine by racemisation. The larger stems contain little alkaloid and should therefore be excluded.

Hyoscyamine is a lævorotatory alkaloid, and atropine is the corresponding inactive racemic compound. Hyoscyamine is racemised by heating or, commercially, by the addition of a small quantity of caustic alkali to its cold alcoholic solution. The same change is produced by ammonia or sodium carbonate solutions and therefore takes place during the official assay process.

Atropine is readily hydrolysed and on heating it at 60° with baryta water the following change takes place :—



Atropine is prepared commercially from *Hyoscyamus muticus*, *Atropa Belladonna*, etc., in which plants the parent alkaloid is *l*-hyoscyamine as in stramonium. Some of the differences between hyoscyamine and atropine are tabulated below :—

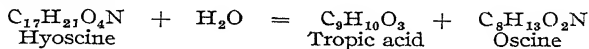
<i>Hyoscyamine</i>	<i>Atropine</i>
Melting point, 108.5°.	Melting point, 114° to 116°.
Solution lævorotatory.	Solution optically inactive.
Sulphate deliquescent.	Sulphate slightly efflorescent.
Picrate melting at 165°	Picrate melting at 175° to 176°.

Adulteration.—The characters described above are sufficient to distinguish most adulterants. The drug has been somewhat frequently adulterated, particularly with the leaves of species of *Xanthium* (Compositæ), *Carthamus* (Compositæ), and *Chenopodium* (Chenopodiaceæ). These are, however, easily distinguished from the genuine drug.

Allied Drugs.—The leaves of the Indian species *D. innoxia* and *D. metel* formed the datura leaves of the 1914 Pharmacopœia. They contain about 0.5 per cent. of the alkaloid *l*-hyoscyamine or *l*-scopolamine, the hydrobromide of which is official. The rhizomes and leaves of *Scopolia carniolica* also form a commercial source of this alkaloid. In the latter plant some of the racemic base also appears to be present, Merck finding that the hydrobromide from *Scopolia* had a rotation of -13.47° . Pure *l*-hyoscyamine hydrobromide has a rotation of

—25.9° and *d*-hyoscyne hydrobromide a rotation of +26.3° cf. official requirement for Hyoscinæ Hydrobromidum).

On hydrolysis hyoscyne yields tropic acid and a base known as oscine :—



The commercial leaves of *D. innoxia* and *D. metel* are curled and twisted like those of stramonium, but are usually somewhat browner in colour. They are distinguished from stramonium by their more entire margins, and differences in venation and trichomes.*

Uses.—Stramonium leaves are used in the treatment of asthma. Atropine has a stimulant action on the central nervous system and depresses the nerve endings to the secretory glands and plain muscle, whence its use to check the night sweats of phthisis and to relieve pain. Hyoscyne is employed as a hypnotic as it does not produce a stimulating effect on the brain although it depresses nerve endings. Hyoscyamine is intermediate in action between atropine and hyoscyne. Atropine and hyoscyne are largely used in ophthalmic practice to dilate the pupil of the eye.

Stramonium Seeds (Fig. 195, G) are dark brown or blackish in colour, reniform in outline, and about 3 mm. long. The testa is reticulated and finely pitted. A longitudinal section shows a coiled embryo embedded in an oily endosperm.

Stramonium seeds contain about 0.2 per cent. of mydriatic alkaloids resembling those of the leaves and about 15 to 30 per cent. of fixed oil. They are used for the same purposes as the leaves.

Datura Seeds are derived from *D. metel* and possibly other species. They are used in India in the same way as stramonium seeds. Each seed is light brown in colour, and ear-shaped. They are larger and more flattened than stramonium seeds, but resemble the latter in internal structure. They contain 0.2 per cent. of alkaloids, consisting of hyoscyne with traces of hyoscyamine and atropine.

HYOSCYAMI FOLIA

Hyoscyamus, B.P. ; *Hyoscyamus Leaves* ; F. *Feuilles de Jusquiame* ; G. *Bilsenkrautblätter*

Source.—*Hyoscyamus* consists of the dried leaves and flowering tops of *Hyoscyamus niger*. The description of the

* For details see Timmerman, *Y. B. Pharm.*, 1927, 467.

official drug refers to petiolate as well as sessile leaves, the first biennial leaves being thus admitted. Henbane is cultivated in England but considerable quantities are imported from Central Europe. The plant is also cultivated in the U.S.A.

Plant.—Henbane is a biennial (var. *α-biennis*) or annual (var. *β-annua*) plant. It is found wild, chiefly near old buildings, both in England and on the Continent, and is widely cultivated. Before examining commercial henbane leaves it is advisable to study growing plants or herbarium specimens. The following differences should be noted :—

<i>First Year Biennial.</i>	<i>Second Year Biennial.</i>	<i>Annual.</i>
Stem very short.	Stem branched and up to 1·5 metres high.	Stem simple and about 0·5 metre high.
Leaves in a rosette near the ground. Ovate-lanceolate and petiolate, up to 30 cm. long, the lamina being up to 25 cm. long. Hairy.	Leaves sessile, ovate-oblong to triangular-ovate, 10 to 20 cm. long. Margin deeply dentate or pinnatifid. Very hairy, especially in the neighbourhood of the midrib and veins.	Leaves sessile. Smaller than those of the biennial plant, with a less incised margin and fewer hairs.
Does not normally flower in the first year.	Corolla yellowish, with deep purple veins.	Corolla paler in colour and less deeply veined.

Henbane flowers have the formula $K(5), C(5), A_5, G(2)$. The hairy five-lobed calyx is persistent. The fruit is a small, two-celled pyxis, which contains numerous seeds.

Henbane seeds are dark-grey in colour, somewhat reniform in shape, and about 1·5 mm. long. They have a minutely reticulated testa and an internal structure closely resembling that of stramonium seeds. Henbane seeds contain about 0·06 to 0·10 per cent. of alkaloids (hyoscyamine with a little hyoscine and atropine).

History.—Henbane, probably the Continental *H. albus*, was known to Dioscorides and was used by the ancients. Henbane was used in England during the Middle Ages. After a period of disuse in the eighteenth century the drug was restored to the London Pharmacopœia of 1809 largely owing to the work of Störck.

Collection and Preparation.—Biennial henbane is the variety mainly grown in England, but much of the imported drug is of the annual variety or is derived from the allied species

H. albus. As previously mentioned (p. 59) the germination of henbane seeds is slow and often erratic. It is stated in the U.S. Dispensatory that the seeds germinate more satisfactorily if they are first treated with concentrated sulphuric acid and thoroughly washed with water. Fairly uniform germination is then said to take place in from twelve to fifteen days.

The annual plant usually flowers in July or August and the biennial in May or June. In England the drug appears to be collected at a somewhat earlier stage than on the Continent, *i.e.* when flowering rather than fruiting. The leaves should be dried rapidly, preferably by artificial heat at a temperature of about 40° to 50°.

Macroscopical Characters.—Commercial henbane consists of the leaves and flowering tops described above. The leaves are more or less broken but are characterised by their greyish-green colour, very broad midrib, and great hairyness. If not perfectly dry they are clammy to the touch owing to the secretion produced by the glandular hairs. The stems are mostly less than 5 mm. in diameter and are very hairy. The flowers are compressed or broken, but their yellowish corollas with purple veins are often seen in the drug. Henbane has a characteristic, heavy odour and a bitter, slightly acrid taste.

Microscopical Characters.—A transverse section of a henbane leaf shows a bifacial structure. Both surfaces have a smooth cuticle, epidermal cells with wavy walls, stomata of solanaceous type and large number of hairs, which are particularly abundant on the midrib and veins. The hairs are up to 300 μ in length; some are uniseriate and about four cells long, while others have a uniseriate stalk and a large, ovoid, glandular head, the cuticle of which is often raised by the secretion (see Fig. 197). Similar hairs are found on the stems. The mesophyll contains single prisms, twin prisms, cluster crystals, and a few microspheñoidal crystals of calcium oxalate. In the broad midrib the epidermis is readily separated and the underlying tissue, which in stramonium is collenchymatous, is parenchymatous and shows intercellular spaces. The vascular tissue of the midrib is broader than in stramonium but shows the usual bicollateral arrangement, which is also found in the stems. For further details, see powder, p. 106.

Constituents.—Henbane leaves contain about 0.045 to 0.14 per cent. of alkaloids (official minimum 0.05 per cent.) and yield about 8 to 12 per cent. of ash (officially not more than 20 per cent.). Hyoscyamine is the chief alkaloid present, but

it may be accompanied by a little hyoscyine and atropine. The petiole appears to contain more alkaloid than the lamina or stem.

Much of the Continental drug is said to consist of *H. albus*, which contains about 0.20 to 0.56 per cent. of alkaloids (mainly hyoscyamine). Egyptian henbane, from *H. muticus*, is also imported for the preparation of hyoscyamine. The Egyptian leaves have yielded 1.4 per cent. of alkaloids and the leaves and stems 0.6 per cent.

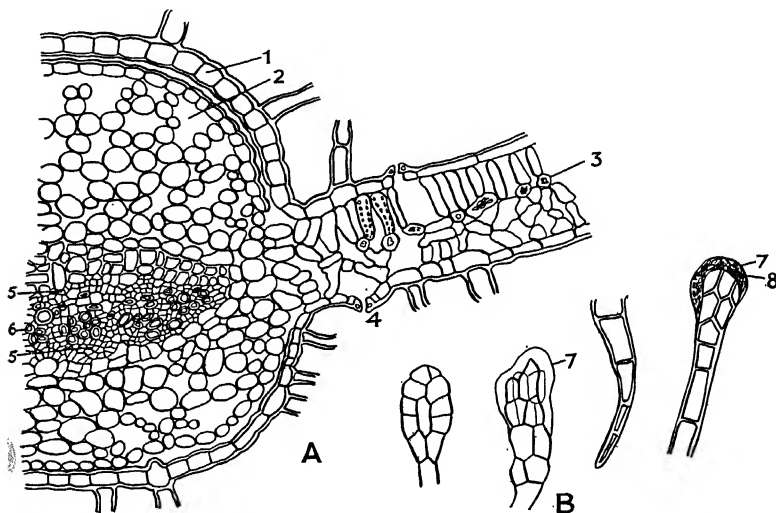


FIG. 197.—*Hyoscyamus niger*. A, transverse section of leaf; B, hairs. 1, epidermis; 2, intercellular space; 3, twin prism of calcium oxalate; 4, stoma; 5, phloem; 6, xylem; 7, cuticle; 8, secretion. (After Tschirch-Oesterle, *Atlas*.)

Allied Drugs.—*Hyoscyamus albus*, which is grown on the Continent, particularly in France, has petiolate stem leaves. The flowers have pale yellow, non-veined corollas.

Hyoscyamus muticus is indigenous to India and Upper Egypt; it has been introduced into Algiers. The leaves are petiolate, entire or dentate, and are usually found with a considerable amount of yellowish stalk. Some samples consist almost entirely of stalks and fruits. The corolla is yellowish-white and the pyxis, unlike that of *H. niger*, is cylindrical.

Uses.—Henbane resembles belladonna and stramonium in action but is somewhat weaker. It is often used with purgatives such as colocynth to prevent griping.

BELLADONNÆ FOLIA

Belladonnæ Folium, B.P. ; *Belladonna Leaves* ; F. *Feuilles de Belladonne* ; G. *Belladonnablätter*, *Tollkirchenblätter*

Source.—The drug consists of the dried leaves and tops of *Atropa Belladonna*, collected when the plant is in flower. Some of the drug is obtained from plants grown in Britain, but much is imported from the Continent. It is also cultivated in India and the U.S.A.



FIG. 198.—*Atropa Belladonna*, showing leaves, flowers, and fruits (Sutcliffe).

Plant.—The deadly nightshade or belladonna is a perennial herb which attains a height of about 1.5 metres. The plant shown in Fig. 198 is four or five years old. Owing to adnation the leaves on the upper branches are in pairs, a large leaf and a smaller one (see Fig. 199, A).

The flowers appear about the beginning of June. They are solitary, shortly stalked, drooping, and about 2.5 cm. long. The corolla is campanulate, five-lobed, and of a dull purplish colour. The five-lobed calyx is persistent, remaining attached to the purplish-black berry. The latter is bilocular, contains numerous seeds, and is about the size of a cherry. In the U.S.A. the plant is often known as the "Poison Black Cherry," while the German name is "Tollkirchen" (*i.e.* Mad Cherry).

History.—Belladonna was probably known to the ancients but it is not clearly recorded until the beginning of the sixteenth century. The leaves were introduced into the London Pharmacopœia of 1809, but the root was not used in Britain until a liniment prepared from it was introduced by Squire in 1860.

Cultivation, Collection, and Preparation.—Belladonna is grown either from seed or by dividing the rootstocks of old plants. The leaves are said to be richest in alkaloid at the end of June or in July, and a sunny position is said to give more active leaves than a shady one. Plants about three years old are sufficiently large to give a good yield of leaves and, if the roots are being collected, it would seem to be best to replant about every third year (see also belladonna root). Two or even more crops of leaves may be collected annually. Leaves left in an imperfectly dry state deteriorate and give off ammonia. They should therefore be dried immediately after collection and be carefully stored. Sometimes the leaves are badly attacked by insects (see portions of leaves eaten away in Fig 198), and the roots by a fungus.*

Macroscopical Characters.—The drug consists of leaves and the smaller stems, the latter seldom exceeding 5 mm. in diameter. If the drug is little broken the arrangement of the leaves in unequal pairs may be seen. The leaves are dull green or yellowish-green in colour, the upper side being somewhat darker than the lower. Each has a petiole of somewhat variable length and a broadly ovate, slightly decurrent lamina about 5 to 25 cm. long and 2.5 to 12 cm. wide. The margin is entire and the apex acute. A few flowers and fruits may be found. If the leaves are broken the most useful diagnostic characters are the venation and roughness of the surface. The latter is due to the presence of calcium oxalate in certain of the mesophyll cells, which causes minute points on the surface of the leaf as the other cells contract more on drying.

* See Alcock, "A Preliminary Note on the *Phytophthora* on *Atropa Belladonna*," *P.J.*, 1926, Feb. 27, 232.

Microscopical Characters.—A transverse section and surface preparations of belladonna leaves are shown in Fig. 199. Stomata of characteristic solanaceous type are present on both surfaces, but are most common on the lower. The epidermal cells have sinuous walls and a striated cuticle. In the mesophyll certain of the cells are filled with microspenoidal ("sandy") crystals of calcium oxalate. The midrib shows the usual solanaceous structure. Hairs are most numerous on the young leaves. Some of the hairs are uniserial, two- to four-celled, clothing hairs, others resemble these but have a unicellular glandular head, while a third kind has a short pedicel and a multicellular glandular head. For further details, see powder, p. 107.

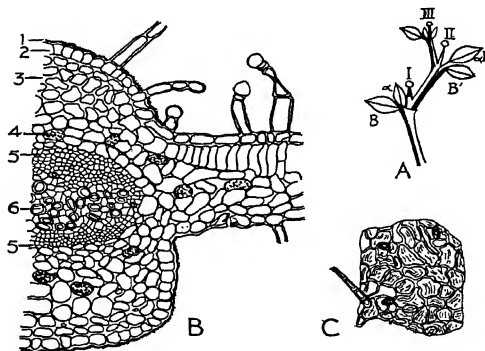


FIG. 199.—*Atropa Belladonna*. A, diagram of flowering region; B, transverse section of leaf; C, portion of lower epidermis of same. 1, cuticle; 2, epidermis; 3, collenchyma; 4, sandy crystals of calcium oxalate; 5, phloem; 6, xylem. (A after Eichler; B and C after Tschirch-Oesterle, *Atlas*.)

Constituents.—Belladonna leaves contain from 0.15 to 0.60 per cent. of alkaloids (average about 0.4 per cent., official minimum 0.3 per cent.), the chief of which is hyoscyamine. Small quantities of volatile bases, such as pyridine and N-methylpyrroline, are present, and if not removed during the assay of the drug by heating would increase the titration and appear in the result as hyoscyamine.

The leaves also contain a fluorescent substance,* β -methyl-

* Infusions of all the solanaceous drugs examined give a distinct fluorescence in ultra-violet light. β -methylæsculetin and other fluorescent substances are widely distributed in the Solanaceæ and allied families.

æsculetin (scopoletin), and calcium oxalate. They yield about 14 per cent. of ash (official limit 15 per cent.).

Allied Drugs.—*Scopolia leaves* † are dried leaves of *Scopolia carniolica*, a European solanaceous plant which is somewhat smaller than belladonna. The leaves resemble those of belladonna in shape, although more lanceolate and translucent. The cuticle is striated but less markedly so than in belladonna, sandy crystals are less numerous, hairs are rare or absent, and stomata are present on the lower surface only. The fruit, which is a pyxis, may often be found in the drug. The leaves are suitable for alkaloid manufacture since they contain about 0.5 per cent. of hyoscyamine and hyosine. *Scopolia* rhizomes are used for the same purpose.

Adulterants.—Of the numerous recorded adulterants of belladonna leaves those of *Phytolacca decandra* * (Phytolaccaceæ) and *Ailanthus glandulosa* * (Simarubiaceæ) are perhaps the most important. In *Phytolacca* the lamina is denser and less decurrent than in belladonna; the epidermal cells have straight walls, and some of the mesophyll cells contain bundles of needle-shaped crystals of calcium oxalate. *Ailanthus* leaves are triangular-ovate, have whitish unicellular hairs on both surfaces, and contain cluster crystals of calcium oxalate.

Uses.—Belladonna leaves are mainly used for internal preparations which are used as sedatives and to check secretion. Preparations of the root are mainly used externally.

BELLADONNÆ RADIX

Belladonnæ Radix, B.P.; *Belladonna Root*; F. *Racine de Belladonne*; G. *Belladonnawurzel*

Source.—The drug consists of the dried roots of *Atropa Belladonna*. It is collected in England and on the Continent.

Collection and Preparation.—Much of the commercial drug is of small size and poor quality. The first year roots are not profitable to collect from the commercial point of view, although they contain a high proportion of alkaloids. The autumn of the third year would seem to be a suitable time for collection. The roots are dug up, washed, sliced, and dried.

Macroscopical Characters.—Belladonna rapidly develops a large, branching root. The aerial stems die back each year

* For illustration of these leaves, see Wallis, *Practical Pharmacognosy*, p. 28.

and new ones arise independently from the large crown. By slicing the latter in the autumn the number of plants may be increased.

Belladonna grown at Edinburgh produced in its first year a root about 20 cm. long and 1 to 2 cm. in diameter, while a four-year-old plant had a crown 10.5 cm. in diameter which weighed with the roots about 20 lb.* Dried roots of three-year-old plants are about 3 cm. in diameter and roots over 4 cm. in diameter are exceptional. Most of the commercial drug is only about half this thickness.

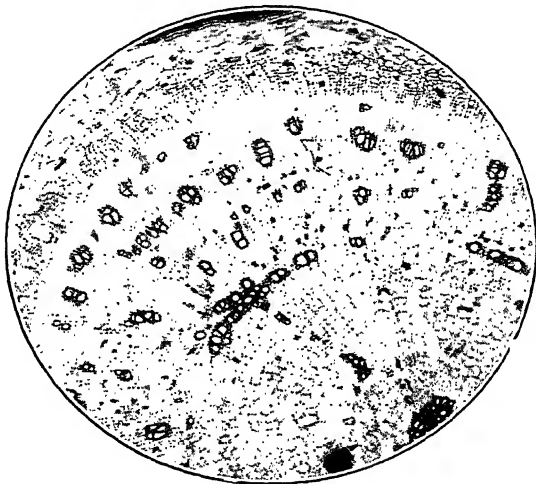


FIG. 200.—*Atropa Belladonna*. Transverse section of root (Sutcliffe).

The drug is usually cut into short lengths, which are sometimes split longitudinally. The outer surface is a pale greyish-brown. The root breaks with a short fracture and then shows a whitish or, if overheated during drying, brownish interior. A yellowish-green colour in the neighbourhood of the cambium is often seen.

Microscopical Characters.—A transverse section of a typical root is shown in Fig. 200. The cork consists of a few layers of

* A photograph of this root will be found in the *P.J.*, 1926, Feb. 27, 231. A similar specimen found in a commercial sample of the drug was presented to us some years ago. Such large pieces, although easily grown, are rarely met with in commerce.

thin-walled cells. The bark is non-fibrous and the wood does not show a radiate appearance. The wood consists of scattered groups of vessels, tracheids, and fibres, which are most abundant near the cambium; there is a central mass of primary xylem. The parenchyma of bark and wood contains sandy crystals of calcium oxalate and abundant simple and compound starch grains.

The structure gradually changes as the roots pass into rhizome, the wood becoming denser and exhibiting a distinctly radiate structure; the rhizome also shows a distinct pith and internal phloem. The aerial stems found on the upper surface of the crown are hollow.

Constituents.—Belladonna root contains about 0.4 to 0.8 per cent. of alkaloids calculated as hyoscyamine. Experiments made by Blackie * with regard to the alkaloidal content at different ages bear out the statement of Schmidt that the younger roots contain the most alkaloid. Gerrard, however, found the roots to be most active in the fourth year. The following figures obtained by Blackie may be compared with the official requirements (not less than 0.4 per cent. of alkaloids and not more than 4 per cent. of acid-insoluble ash) :—

	Alkaloids.	Acid-Insoluble Ash.
First year	0.72 per cent.	1.10 per cent.
Second year	0.65 "	0.61 "
Third year	0.66 "	1.50 "
Fourth year	0.60 "	0.83 "

Belladonna root also contains β -methylæsculetin, calcium oxalate, and starch.

Allied Drugs.—*Bulgarian belladonna* root has recently received considerable attention in the treatment of Parkinson's disease. When first introduced it was considered that the root was in some way different from ordinary belladonna root, but examination shows that it has the normal macroscopic and microscopic characters of *Atropa Belladonna*. Samples contain from 0.24 to 0.58 per cent. of alkaloids. Further clinical, pharmaceutical, and chemical investigations are proceeding.†

Two kinds of *Indian belladonna* may be met with in commerce, one derived from cultivated plants of *Atropa Belladonna*

* Blackie, *P.J.*, 1926, Feb. 27, 231.

† See Bailey, *P.J.*, 1938, 86, 77 and 567; also *Y.B. Pharm.*, 1938, 144.

and the other from wild plants of *Atropa lutescens* Jacquemont. The roots of the latter plant all show a distinctly radiate transverse section even when of small size. They yield about 0·7 per cent. of alkaloids, which require further investigation.

Scopolia rhizome is the dried rhizome of *Scopolia carniolica*. It contains about 0·6 to 0·7 per cent. of alkaloids and is imported for the manufacture of hyoscyamine and hyoscine. It is sometimes found in Continental samples of belladonna root. The plant grows in the Carpathians, Czechoslovakia, and Roumania. The rhizomes bear little resemblance to belladonna since they are nearly black in colour and bear numerous depressed stem scars. They are about 2 cm. in diameter and up to 10 cm. in length, but are usually much shorter.

"*Japanese Belladonna Root*" is the rhizome of *Scopolia japonica*. This resembles the European scopolia rhizome but contains only about 0·2 to 0·3 per cent. of alkaloids (hyoscyamine and norhyoscyamine).

Adulterant.—The root of *Phytolacca decandra* (Fam. Phytolaccaceæ) is sometimes sliced and mixed with samples of belladonna. It bears little resemblance to belladonna root, but a casual and inexperienced observer might perhaps mistake it for pieces of an old belladonna crown. The transverse section shows a number of concentric cambia, each producing a ring of wood bundles. The parenchyma contains abundant acicular crystals of calcium oxalate. A purgative substance (phytolaccin), of resinous nature, is also present.

CAPSICI FRUCTUS

Capsicum, B.P. ; *Capsicums*, *Chillies* ; F. *Poivre de Guinée* ; G. *Spanischer Pfeffer*

Source.—The drug official in the British Pharmacopœia is described as the dried ripe fruits of *Capsicum minimum* Roxb., and the description given applies to the commercial varieties known as Sierra Leone, Nyassaland, and Zanzibar chillies. These and a fourth variety, the Japanese, are sold in England as chillies, while the larger but less pungent Bombay and Natal fruits are known on the London market as capsicums. These commercial varieties are illustrated in Fig. 201. Very large *Capsicum* fruits, resembling tomatoes in texture and practically non-pungent, are widely grown in South Europe as vegetables.

The degree of relationship between the plants yielding the above fruits is somewhat doubtful, some botanists separating as distinct species what others regard as cultural varieties. The Japanese fruits are a case in point. They were regarded by Holmes as being partly derived from *C. minimum* Roxb. and probably partly from *C. frutescens* Linn., species which are now often united under the name of *C. frutescens* Will.*

History.—Capsicums appear to be of American origin and were referred to in 1494 by Chanca, a physician who accom-



FIG. 201.—1 to 5, chillies; 1, Sierra Leone; 2, Nyassaland; 3, Zanzibar; 4, Japanese; 5, grown in Nottingham; 6 to 8, fruits of *C. annum*; 6, grown in Nottingham; 7, Bombay; 8, Natal. (Newman.)

panied Columbus on his second voyage to the West Indies. The plants were introduced into India at a very early date, possibly by the Portuguese. "Ginnie Pepper" was well known in England in 1597 and was grown by Gerard.

Macroscopical Characters.—*African Chillies*, as will be seen from Fig. 201, are oblong-conical in shape, 12 to 20 mm. long,

* For example, Thoms' *Handbuch der Pharmazie*, p. 1558, gives "*C. frutescens* Will. (Syn. *C. minimum* Roxb.)." On the other hand, Planchon's *Matière Médicale* states: "Le *C. frutescens* fournit le Piment de Cayenne et le *C. minimum* le Poivre de Guinée." The drug official in the U.S.P. is described as being derived from *C. frutescens* Linn., grown in Africa.

and up to 7 mm. in width. The five-toothed calyx and straight pedicel are together about 20 to 30 mm. long. The amount of calices and pedicels is officially limited to 3 per cent. Samples, of course, vary, but the Sierra Leone and Nyassaland

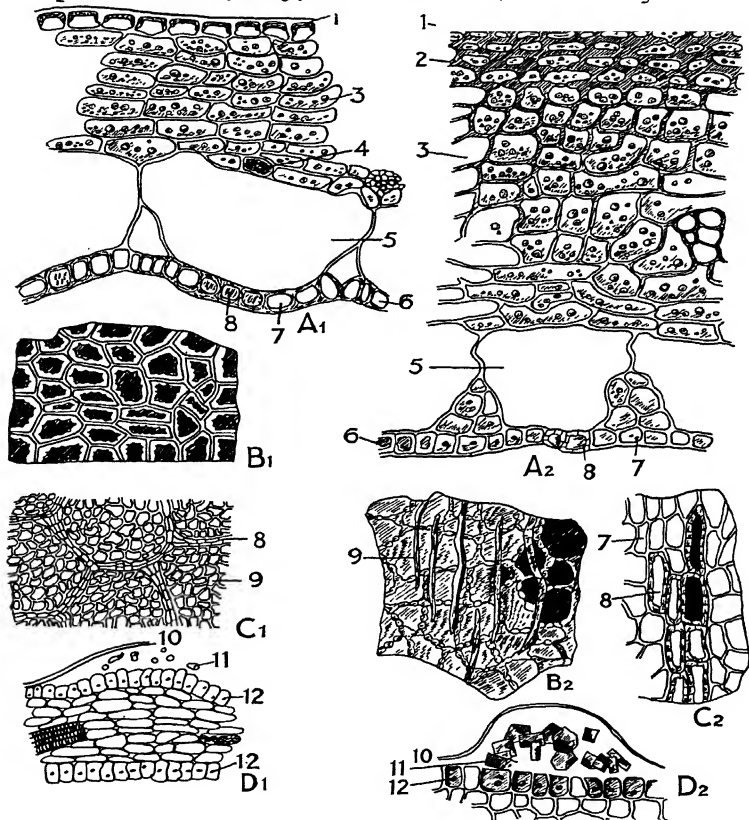


FIG. 202.—A₁ to D₁ *Capsicum minimum*; A₂ to D₂ the corresponding regions of *C. annuum*. A, transverse section of pericarp; B, outer epidermis of same; C, inner epidermis of same; D, transverse section of dissepiment. 1, cuticularised epidermis; 2, collenchymatous hypodermis; 3, parenchyma; 4, sandy crystals of calcium oxalate; 5, large-celled layer; 6, inner epidermis; 7, parenchyma; 8, sclerenchyma; 9, ridges of cuticle; 10, cuticle of dissepiment; 11, secretion; 12, epidermis. (A₁ and D₁ after Wallis, the remainder after Thoms and J. Moeller.)

varieties are usually more free from calices, pedicels, and stalks than the Zanzibar. The pericarp is glabrous, shrivelled and orange-red, the Sierra Leone and Nyassaland usually having a better colour than the Zanzibar.

Internally the fruits are divided into two cells by a membranous dissepiment to which the seeds were originally attached. The latter, usually about ten to twenty in each fruit, are of a flattened reniform shape and are about 3 to 4 mm. long. Like other solanaceous seeds they have a coiled embryo and oily endosperm. African chillies¹ are very sterutatory and have an intensely pungent taste.

Japanese Chillies are about 3 to 4 cm. long. They are usually free from pedicels and calices and have a bright red pericarp. The taste is rather less pungent than the African drug.

Bombay Capsicums are ascribed to *C. annuum* Linn. A typical fruit is shown in Fig. 201, 7. The pericarp is thicker and tougher than in the chillies, and the pedicel is frequently bent.

Natal Capsicums are larger than the Bombay variety and have a very bright red, transparent pericarp. Bombay and Natal capsicums are much less pungent than chillies.

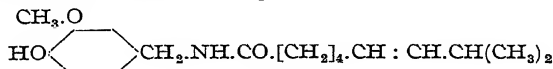
Microscopical Characters.—The microscopical structures of chillies and capsicums are compared in Fig. 202. In the transverse sections of the pericarps, A₁ and A₂, it will be noted that there is a collenchymatous hypoderma in the *C. annuum* only, while in the sections of the dissepiments, D₁ and D₂, the cuticle is seen to be forced up by the secretion of capsaicin. The dissepiment is the most pungent part of the fruit.

The distinguishing characters of the epidermis and hypoderma of the different varieties are summarised by Wallis * as follows :—

<i>C. minimum.</i>	<i>Japanese Chillies.</i>	<i>C. annuum.</i>
Thick and straight-walled rectangular cells with few pits; often arranged in groups of five to seven in a row and with a uniformly striated cuticle. Size of cells, 25 μ to 60 μ in either direction.	Cells with strongly-thickened walls and a radiated lumen. The pits only rarely penetrate the whole thickness of the wall. No visible striation. Size of cells, 30 μ to 80 μ long and 15 μ to 45 μ wide.	Irregular polygonal cells with evenly thickened walls, traversed by numerous, well-marked, simple pits. The cuticle shows striated ridges. Size of cells, 60 μ to 100 μ long and 25 μ to 50 μ wide.

	<i>C. minimum.</i>	<i>Japanese Chillies.</i>	<i>C. annuum.</i>
Hypodermis {	Delicate thin-walled cellulose cells.	A single layer of regular polygonal cells with cuticularised fairly thick walls, traversed by numerous pits, which give them a beaded appearance.	Several layers of cuticularised, collenchymatous cells, having a rounded outline and very few pits.

Constituents.—In 1876 Thresh extracted the drug with petroleum, treated the extract with aqueous alkali, and by passing carbon dioxide through the alkaline liquid precipitated crystals of an intensely pungent compound, capsaicin. As may be inferred from the method of preparation, capsaicin is of phenolic nature. It was synthesised by Nelson and Dawson in 1923 and has the following formula :—



Capsaicin.

The pungency is not destroyed by treatment with alkalis (distinction from gingerol), but is destroyed by oxidation with potassium dichromate or permanganate.

Chillies contain about 0.14 per cent. of capsaicin, red colouring matter, and fixed oil. They yield about 20 to 25 per cent. of alcoholic extract ("capsicin") and about 5 per cent. (official limit 7 per cent.) of ash. Hungarian capsicums are a convenient source of ascorbic acid.

Uses.—Capsicums are used as a condiment under the name of Cayenne pepper. The drug is given internally in atonic dyspepsia and flatulence. It is used externally as a counter-irritant, in the form of ointment, plaster, medicated wool, etc., for the relief of rheumatism, lumbago, etc.

Family **SCROPHULARIACEÆ**

The Scrophulariaceæ comprises 205 genera and about 2,600 species, of which about 30 per cent. are annual herbs and about 64 per cent. perennial herbs and undershrubs. The following subfamilies and genera may be mentioned :—

Subfamily *Pseudosolanoideæ*, e.g. *Verbascum*. Five stamens are often present and there is a marked affinity to the Solanaceæ.

Subfamily *Antirrhinoideæ*, e.g. *Calceolaria*, *Antirrhinum*, and *Scrophularia*. The posterior stamen is absent or barren.

Subfamily *Rhinanthoideæ*, e.g. *Digitalis* and a number of hemiparasites.

The members of the *Scrophulariaceæ* differ from those of the *Solanaceæ* in that they have the carpels placed in an anterior-posterior plane, in the æstivation of the corolla, and in not possessing bicollateral bundles. The flowers are usually zygomorphic and the stamens reduced to four.

Anatomical characters worthy of note are : the glandular hairs in which the head is divided by vertical walls only, and the stomata which are surrounded by three or more epidermal cells. Calcium oxalate is relatively rare ; when present, it occurs in small solitary crystals.

The genus *Digitalis* comprises about 25 species, of which *D. purpurea* and *D. lanata* are of considerable therapeutic importance. Other species of *Digitalis* are known which have a similar medicinal action. The dried rhizome of *Picrorhiza Kurroa*, a Himalayan plant, is used in India as a bitter tonic and was official in the 1914 Pharmacopœia. It is seldom, if ever, used in Britain.

DIGITALIS FOLIA

Digitalis Folium, B.P. ; *Digitalis Leaves*, Purple Foxglove Leaves ; F. *Feuilles de Digitale Pourprée (de Grande Digitale)* ; G. *Purpurrother Fingerhut, Fingerhutblätter*

Source.—The official drug consists of the dried leaves of *Digitalis purpurea* Linn., rapidly dried at a temperature of from 55° to 60° as soon as possible after collection. The leaves are collected from wild or cultivated plants, and either first or second year leaves may be used as they appear to be of similar activity.

Plant.—The foxglove is a biennial or perennial herb, which is very common in England and Europe (except in the Mediterranean region), and is naturalised in North America. In the first year the plant forms a rosette of leaves and in the second year an aerial stem about 1 to 1.5 metres in height. The inflorescence is a raceme of bell-shaped flowers of the floral formula $K(5), C(5), A_4$ didynamous, $G(2)$. The common wild form of the plant has a purple corolla about 4 cm. long, the ventral side of which is whitish but bears deep purple eyespots

on its inner surface. Many varieties, however, exist under cultivation. The fruit is a bilocular capsule which contains numerous seeds attached to axile placentæ.

Cultivation, Collection and Preparation.—*Digitalis* may be readily grown from seed. In the wild state it is usually found



FIG. 203.—*Digitalis purpurea* showing leaves, flowers, and fruits (Sutcliffe).

in semi-shady positions. It grows well in sandy soil provided that a certain amount of manganese is present, this element being apparently essential and always to be found in the ash. Sunshine favours the production of the glycosides and at night they appear to be partially hydrolysed. The leaves should therefore be collected in the afternoon when they have been

illuminated for some hours.* After collection and rapid drying at from 55° to 60°, the leaves should be stored in containers which do not allow access of moisture. Stabilisation by means of alcohol vapour has been recommended.

History.—Foxglove leaves appear to have been used externally by the Welsh "Physicians of Myddvai," but the plant had no name in Greek or Latin until named *digitalis* by Fuchs (1542). The poisonous nature of the leaves was well known, and the drug was recommended by Parkinson in 1640, and it was introduced into the London Pharmacopœia of 1650.

Macroscopical Characters.—*Digitalis* leaves are usually † ovate-lanceolate to broadly ovate in shape, petiolate, and about 10 to 30 cm. long and 4 to 10 cm. wide. The dried leaves are of a dark greyish-green colour. The lamina is decurrent at the base. The margin is crenate or dentate and most of the teeth show a large water pore (Fig. 204, D). Both surfaces are hairy, particularly the lower, and a fringe of fine hairs is found on the margin. The veins are depressed on the upper surface, but very prominent on the lower. The main veins leave the midrib at an acute angle, afterwards branching and anastomosing repeatedly. The drug has no marked odour, but a distinctly bitter taste.

Microscopical Characters.—A transverse section through the midrib of a foxglove leaf shows that it has a normal structure and that it is free from sclerenchymatous fibres, although strengthened by collenchyma. Stomata and hairs are present on both surfaces, but are more numerous on the lower one. The mesophyll is differentiated into palisade and spongy parenchyma, both of which are free from calcium oxalate.

Surface preparations show that the upper epidermis consists of polygonal, relatively straight-walled cells, and bears both clothing and glandular hairs. The cells of the lower epidermis are wavy and the stomata and hairs much more numerous than on the upper surface of the leaf. The stomata are small and slightly raised above the surrounding cells. The clothing hairs are uniseriate, 2 to 7 celled, bluntly pointed and finely warty. The glandular hairs have a unicellular, or occasionally uniseriate, pedicel which bears a unicellular gland. The cuticle of the hairs and epidermal cells may be stained red

* See Dafert, *Biedermann's Zentr.*, 1921, 50, 422, abstracted in *J. Soc. Chem. Ind.*, 1921, 40, 902A.

† Leaves of abnormal shape are sometimes seen, also leaves of very large size. One of the latter at present before the author measures 55 cm. in length and 19 cm. in breadth.

with a solution of Soudan red in glycerin. For powder, see p. 101.

Constituents.—The isolation of the active principles of *Digitalis purpurea* has provided an interesting but extremely

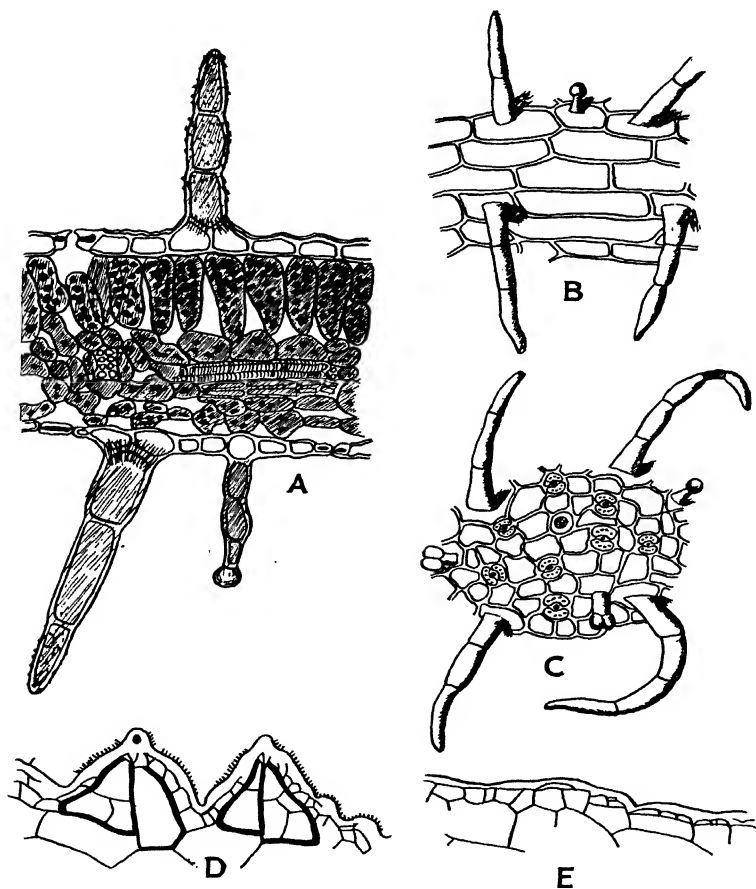


FIG. 204.—*Digitalis purpurea*. A, transverse section of leaf; B, upper epidermis; C, lower epidermis; D, leaf margin of *D. purpurea*; E, leaf margin of *Verbascum Thapsus*. (A after Thoms, *Handbuch der Pharmazie*, B and C after Gilg, D and E after Tschirch.)

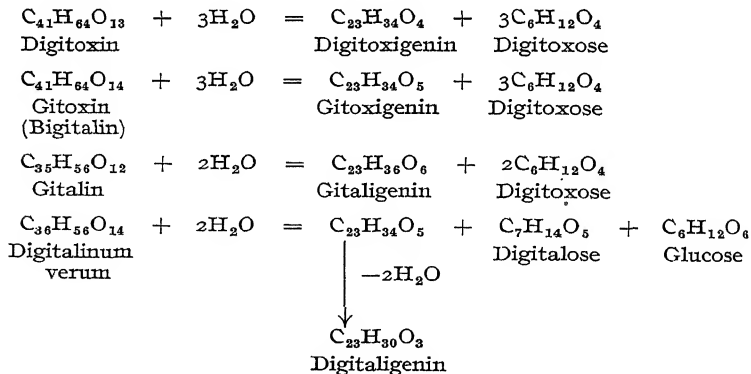
difficult field of research for more than a century. Among the earlier workers may be mentioned Paucquy (1820), Leroyer (1824), Homolle (1844), Kosmann (1844, 1860), Walz (1846 to 1858), Nativelle (1868), Schmiedeberg (1874), and Kiliani (1890 to 1891). The glycosides to which digitalis owes its medicinal action form no definite compounds with chemical reagents and their purification is therefore difficult.

The voluminous literature on the chemistry of digitalis has been much confused by the application of names such as "digitalin" to impure substances isolated by different workers and also to the fact that the seeds, which formed the material of many investigations, contain different constituents from the leaves. The chief constituents of the leaves and seeds are as follows:—

Leaves.—Digitoxin (Digitaline cristallisée, French Codex) 0.2 to 0.3 per cent., gitoxin, and gitalin.

Seeds.—Digitalin (Digitalinum verum), gitalin, digitonin (a saponin), and gitonin.

According to Merz * the chemistry of the glycosides of *D. purpurea* may be summarised as follows:—

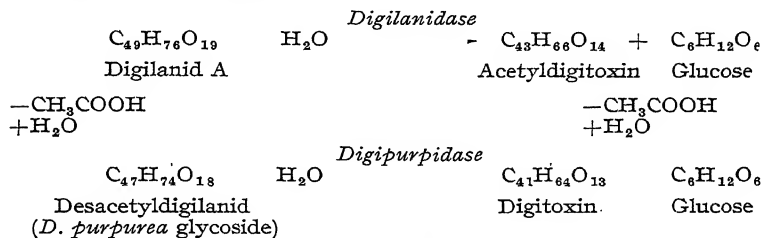


Differences of opinion have existed as to whether these glycosides are initially present in the plant or whether they are degradation products of more complex compounds. Stoll and Kreis (1933), by inhibiting enzyme action, failed to obtain digitoxin but isolated a new glycoside, desacetyldigilanid,

* *Pharm. Ztg. Berl.*, 1933, **78**, 246; abstracted in *Y. B. Pharm.*, 1933, 258. See also Smith, *J.C.S.*, 1930, 508.

having a still stronger action on the heart. On hydrolysis, which may be brought about by an enzyme present in the powdered leaves, it yields glucose and digitoxin.

Constituents of *D. lanata*.—The leaves of *D. lanata* normally contain four glycosides, namely, lanadigin and lanata glycosides II, III, and IV. According to Merz (1933), if enzyme action is excluded three glycosides called digilanid A, B, and C are obtained. Each of these is derived from a different genin and digitoxose (3 mols.), glucose (1 mol.), and 1 acetyl group. Digilanid A is closely related to the initial glycoside of *D. purpurea* mentioned above and both may be converted into digitoxin by specific enzymes (digilanidase and digipurpidase) found in the leaves of the respective species. The changes may be represented :—



For further details on the *Digitalis glycosides*, the published lectures of Stoll may be consulted.*

Keller's Reaction.—The following colour reaction is given by digitoxin and by digitoxose but not by digitoxigenin. The substance is dissolved in glacial acetic acid containing a drop of ferric chloride solution and sulphuric acid is carefully added to form a layer below the acetic acid. A brownish-green band is first formed, after which the acetic acid layer becomes greenish-blue and then indigo-blue, while the sulphuric acid becomes brownish-red. A similar colour reaction is given by *k-strophanthin*.

Allied Drugs.—*Digitalis lanata*, the constituents of which have been mentioned above, is a plant about 1 metre high found in Central Europe. During the last few years the drug has attracted considerable interest and an increasing demand will no doubt lead to its widespread cultivation. The leaves are linear-lanceolate to oblong-lanceolate in shape, up to about 27 cm. long and 4 cm. broad, pubescent on the upper

* Stoll, *The Cardiac Glycosides*, 1937, 51-76.

part but glabrous below. The apex is acuminate, the veins are curved, and the margin is entire or slightly wavy. The vein islet numbers may be used to distinguish *D. lanata* and *D. purpurea* from certain other species, but not from one another. See p. 153.

Digitalis lutea is a yellow foxglove about 0.5 metre high. It is indigenous to southern Europe, but is cultivated in Britain and in the U.S.A. The leaves are about 15 cm. long and 2.5 cm. broad, sessile or amplexicaul, and much less hairy than *D. purpurea*. From the latter they are easily distinguished microscopically by the paucity of non-glandular hairs, the almost complete absence of glandular hairs with unicellular heads, and by the fact that the number of water pores on the marginal teeth varies from 1 to 4 pores on each tooth.*

Digitalis Thapsi is found in Spain and Italy. The leaves have a crenate margin and decurrent lamina. The leaves are characterised by the absence of non-glandular hairs, the striated cuticle of the epidermal cells, and the presence of pericyclic fibres and small prisms of calcium oxalate.† The vein islet number is another useful distinguishing character (see above).

Adulterants.—The characters described above, particularly the margin, venation, and trichomes are sufficient to distinguish the official leaves from all the adulterants which have been recorded. For example, mullein leaves (*Verbascum Thapsus*) are densely covered with branched, woolly hairs and have the margin shown in Fig. 204, E. Other possible adulterants are the leaves of comfrey, elecampane, and primrose.

Uses.—*Digitalis* preparations are mainly used for their action on cardiac muscle.

Order PLANTAGINALES

Family PLANTAGINACEÆ

The Plantaginaceæ includes 203 species, of which 200 belong to the genus *Plantago* (plantain).

* For further details see Dewar, *Y. B. Pharm.*, 1934, 1.

† For further details see Dewar, *Y. B. Pharm.*, 1933, 443.

PLANTAGINACEÆ

PLANTAGINIS SEMEN

PSYLLIUM and ISPAGHULA

Sources.—The dried, ripe seeds of *Plantago Psyllium*, *P. arenaria* and *P. ovata* are used in medicine. The U.S. National Formulary includes all three species under the name Plantaginis Semen. In the British Pharmaceutical Codex the seeds of the first two species are included as Psyllium B.P.C., whilst those of *P. ovata* form Ispaghula B.P.C., the name under which they were official in the B.P. 1914.

The seeds of *P. Psyllium* and *P. arenaria* are known in commerce as Spanish or French psyllium, whilst those of *P. ovata* are known as blonde psyllium, ispaghula, spogel seeds or Indian plantago seeds.

Characters.—Some of the more important characters of these seeds are as follows * :—

	<i>P. Psyllium.</i>	<i>P. arenaria.</i>	<i>P. ovata.</i>
<i>Colour</i>	Glossy ; deep brown.	Dull ; blackish-brown.	Dull ; pinkish grey-brown.
<i>Shape</i>	Boat-shaped ; outline elongated ovate.	Boat-shaped ; outline elliptical.	Boat-shaped ; outline ovate.
<i>Length</i>	2.0–3.0 mm.	2.0–2.5 mm.	1.8–3.3 mm.
<i>of 100 seeds</i>	0.09–0.10 G.	0.12–0.14 G.	0.15–0.19 G.

Constituents.—All the seeds contain mucilage in the epidermis of the testa. The seeds may be evaluated by measuring the volume of mucilage produced in 24 hours from 1 G. of seeds. This is termed the *swelling factor*, and in the samples examined by Skyrme and Wallis was 12.75 for *P. Psyllium* (1 sample), 14.50 for *P. arenaria* (1 sample), and 10.25–13.50 for *P. ovata* (7 samples). The seeds also contain fixed oil and protein.

Uses.—Plantago seeds are used as demulcents and in the treatment of chronic constipation. Ispaghula husk (Ispaghulæ Testa, B.P.C.) is used for similar purposes but has a higher swelling factor (about 90).

* For further details and microscopy, see Skyrme and Wallis, *Y.B. Pharm.*, 1936, 198 ; also Skyrme, *Y.B. Pharm.*, 1935, 1 and 161.

Order RUBIALES

The remaining orders, namely the Rubiales and Campanulales, comprise families in which the ovary is inferior. The Rubiales includes the families Rubiaceæ, Caprifoliaceæ, and Valerianaceæ. Of these the members of the Rubiaceæ and Caprifoliaceæ are mainly woody and the Valerianaceæ herbaceous. The flowers are typically regular in the Rubiaceæ, regular or medianly zygomorphic in the Caprifoliaceæ, while in the Valerianaceæ the flower is markedly zygomorphic and there is reduction in the number of stamens and fertile loculi.

Family RUBIACEÆ

The Rubiaceæ is very closely allied to the Caprifoliaceæ. It includes 380 genera and about 4,600 species, most of which are tropical trees and shrubs. The following subfamilies and genera may be noted :—

Subfamily *Cinchonoideæ*.—Carpels typically with numerous ovules, e.g. *Cinchona* (about 40 species) and *Uncaria*.

Subfamily *Coffeoidæ*.—Carpels with a solitary ovule, e.g. *Coffea* * (28 species), *Cephaelis*, and the British species of *Rubia* (madder), *Asperula* (woodruff), and *Galium* (bedstraws, crosswort, cleavers, etc.).

CINCHONÆ CORTEX

Cinchona, B.P., *Cortex Chinæ*, *Cinchonæ Rubræ Cortex* ;
Cinchona Barks, *Red Cinchona Bark* ; F. *Écorces de*
Quinquinas ; G. *Chinarinde*, *Rothe Chinarinde*

Source.—The official drug is “the dried bark of cultivated trees of *Cinchona Calisaya* Weddell, *Cinchona Ledgeriana* Moens, *Cinchona officinalis* Linn., *Cinchona succirubra* Pavon, and of hybrids of either of the last two species with either of the first two.” The official alkaloids may be obtained from

* See p. 405.

any suitable bark. *Cinchona robusta* Howard is mentioned in the Pharmacopœia as a suitable source of Totaquina.*

The Cinchonas are indigenous to the Andes (Colombia, Equador, Peru, and Bolivia), where they grow at a height of about 4,000 to 7,000 feet. The natural distribution of some of the more important species is as follows :—

- (i) Colombia.—*C. lancifolia* Mutis.
- (ii) Equador.—*C. officinalis* Linn.
- (iii) Peru.—*C. officinalis* Linn., *C. succirubra* Pav., *C. micrantha* R. et P.
- (iv) Bolivia.—*C. Calisaya* Wedd. and *C. Ledgeriana* Moens.†

At the present time some 90 per cent. of the world's supply of cinchona is produced by the Dutch, mainly in western Java. A considerable quantity is also produced in India (Himalayas near Darjeeling and in the Neilgherry Hills, etc.), whilst smaller quantities are obtained from Ceylon, South America (where the trees are now cultivated), Jamaica, Tanganyika, etc.

History.—The natives of South America do not appear to have been acquainted with the medicinal properties of cinchona bark, the bitter taste of which inspired them with fear. Although Peru was discovered in 1513 the bark was first used for the cure of fevers about 1630. In 1638 the corregidor of Loxa, who had himself been cured by the bark eight years earlier, sent some of the drug to the physician of the viceroy of Peru, whose wife, the Countess of Chinchon, was at that time suffering from fever. On her recovery she caused the bark to be distributed to other patients. The remedy, which became known as "Pulvo de la Condesa," acquired a considerable reputation and was known in Spain in 1639. The further distribution of the bark was largely due to the Jesuit priests, and the drug became known as Jesuit's Powder or

* I am indebted to Mr. T. E. Wallis for the following information on this bark : "*Cinchona robusta* is not a definite species of *Cinchona*. It is a hybrid between *C. officinalis* and *C. succirubra* or, as some say, between *C. officinalis* and *C. Calisaya*. It comes partly from Java and also from India and Ceylon. It has also been grown in Tanganyika. In characters it is intermediate between *officinalis* and *succirubra* ; it shows externally a wrinkling somewhat resembling that on *succirubra*, but more irregular and with numerous small warty points. In colour it is more like *C. officinalis* and on some pieces there are numerous transverse cracks intermediate in form between those of *succirubra* and *officinalis*. *C. robusta* contains more cinchonidine than quinine and about 5 to 27 per cent. of cinchotannic acid."

† Sometimes regarded as a variety of *Calisaya*, sometimes as a hybrid between *C. Calisaya* and *C. micrantha*.

Peruvian Powder. It first appeared in the London Pharmacopœia in 1677 under the name of Cortex Peruanus.

Until 1737 the trees yielding the drug were unknown to science, but in that year the astronomer Condamine, who visited Loxa to measure a degree of the earth's surface at the Equator, obtained specimens of the tree now known as *C. officinalis*. Jussieu, the botanist of the same expedition, discovered a second species, *C. pubescens*, in 1739. Other species were discovered and described by Mutis (1760), Ruiz and Pavon (1778 to 1788), and Weddell (1845 to 1848).

The bark was originally obtained by felling the wild trees, and as none were replanted the trees were exterminated in many districts. Ruiz (1792) and Royle (1839) suggested the cultivation of Cinchonas in other parts of the world. Weddell germinated seeds in Paris in 1848 and the plants were introduced into Algiers in the following year but without much success. A further attempt by the Dutch was made in 1854, seeds and plants being obtained from Peru by Hasskarl and introduced into Java. An English expedition under Markham in 1860 led to the introduction of *C. succirubra*, the most hardy species, *C. Calisaya*, and *C. micrantha* into India. Seeds of *C. Ledgeriana* were obtained in Bolivia by Charles Ledger in 1865 and were bought by the Dutch for their Javanese plantations. Ledger bark is particularly rich in quinine and is grown in India as well as in Java. The wide use of other cinchona alkaloids, however, compensates for the relatively low quinine content of species such as *C. succirubra*.

Cultivation, Collection, and Preparation.—The cultivation of Cinchonas is one which presents a number of difficulties. Attention must, of course, be paid to climate and to elevation. In addition, hybridisation takes place very readily, and although some of the hybrids are commercially valuable others are almost worthless. An enormous amount of research has been done on the subject, particularly by the Dutch.*

Uprooting System.—The following method is the one now mainly used: The plants are raised from seed and when of suitable size are planted out a few feet apart, the distance varying somewhat according to the species. At the end of six or seven years the plantation is thinned out by uprooting certain of the trees and collecting the bark from both their

* The following notes are mainly derived from *Chinin in der Allgmeinpraxis*, by F. Johannessohn, Amsterdam (1930). Some idea of the extensive literature on quinine may be gathered from the fact that this book gives no less than 652 references to papers on quinine and 157 to those on quinidine.

stems and roots. Every year a further thinning takes place, until after fifteen to twenty-five years only about 25 per cent. of the original trees are left. All are then uprooted.

The procedure is as follows: After removing the branches, the stem is cut off about 1.5 metres from the ground, and the stump dug out. After the roots have been cleaned and separated the bark is removed by means of a bone knife, iron being avoided owing to its effect on the tannin in the bark. The stem and branch bark is easily separated after cutting and loosening by tapping. This work is mostly done by women.

The finest quills, "Druggists' bark," usually have a quinine content of about 1.8 to 2 per cent. and their value depends to a considerable extent on their appearance and on the amount of secondary alkaloids and tannins which they contain. They are usually cut into standard lengths and packed in cases. The "factory bark," is often broken and compressed, and is valued on the quinine content, which averages about 6 per cent.

Coppicing System.—This system is now said to be used only on the smaller plantations. When the trees are about seven or eight years old they are cut down and stripped for bark. Adventitious shoots arise from the stool and form a thick bush. When these have attained a suitable size they are cut and yield fine "druggists' quills" of bark. After some years the tree is dug up and the very rich root bark also obtained.

Other Systems.—The following systems are now mainly of historical interest. Cinchona cultivation in India owes much to MacIvor, who in 1863 introduced the *mossing system* to replace the wasteful system of felling previously used.* Strips of bark about 4 cm. wide were removed and the wound covered with moss. After an interval to allow for the formation of new bark further strips were removed from the portions of trunk left untouched by the previous collection. Subsequently the strips of "renewed" bark, having a high alkaloidal content, were also removed. This procedure and a similar one in which only a portion of the bark was shaved off (*shaving system*), although improvements on the *felling system*, were too expensive to compete with the uprooting system, which as mentioned above is the one now usually adopted.

General Characters.—A. *Stem Bark.*—The commercial "druggists' quills" are up to 30 cm. in length and usually 2 to 6 mm. thick. Bark for manufacturing purposes is frequently in

* MacIvor, *A letter on the Cultivation of Chinchona on the Nilgiris* (1876). The plant named *C. MacIvoriana* is a hybrid closely resembling *C. robusta*.

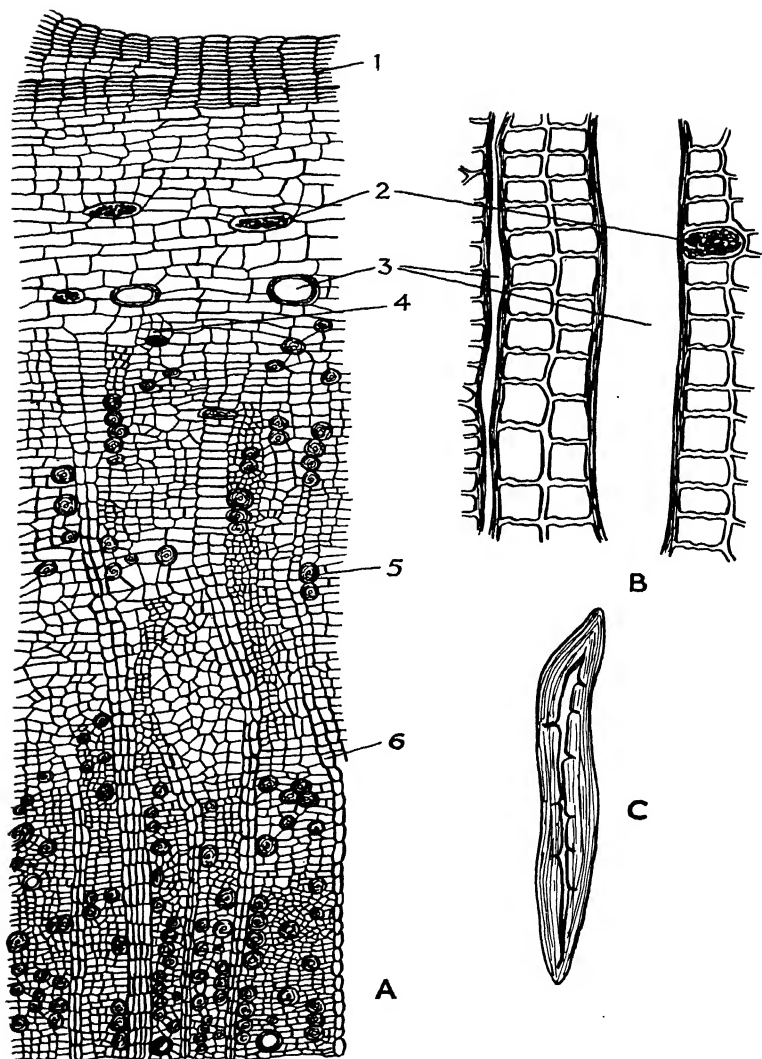


FIG. 205.—*Cinchona succirubra*. A, transverse section of bark; B, longitudinal section through latex tubes; C, fibre. 1, cork; 2, calcium oxalate; 3, latex tube; 4, primary phloem; 5, fibre of secondary phloem; 6, medullary ray. (After Tschirch-Oesterle, *Atlas*.)

small curved pieces. The outer surface frequently bears moss or lichen. The cork may or may not be longitudinally wrinkled and usually bears longitudinal and transverse cracks, which vary in frequency and distinctness in the different

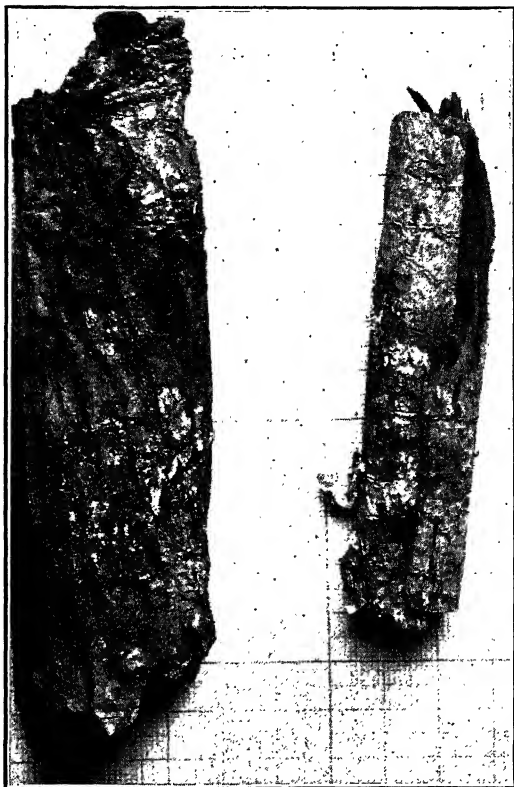


FIG. 206.—Bark of *Cinchona succirubra* (Newman).

varieties. The inner surface is striated and varies in colour from yellowish-brown to deep reddish-brown. The fracture is short in the outer part but somewhat fibrous in the inner part. Odour, slight; taste, bitter and astringent.

The bark gives the thalleioquin test (see Y.B. Pharm. 1938),

a reaction for phlobatannins, and if moistened with a drop of acid shows a bright blue fluorescence in ultra-violet light.

B. *Root Bark*.—Root bark occurs in channelled, often twisted pieces about 2 to 7 cm. long. Both surfaces are of similar colour, the outer, however, being somewhat scaly, whilst the inner surface is striated. Root bark also responds to the chemical tests mentioned above.

Microscopical Characters.

—Cinchona barks have the general microscopical structure shown in Fig. 205. The cork cells are thin-walled and more or less reddish in colour. In the cortex are idioblasts containing microcrystals of calcium oxalate, secretion cells which in old barks are almost devoid of contents, whilst the remaining cortical cells contain amorphous, reddish-brown matter or small starch grains. The phloem consists of sieve tissue, phloem parenchyma, and isolated bast fibres. The latter, which are often arranged in irregular, radial rows, differ in size and distribution in the different species (see below). The root bark contains sclereids. For powder, see p. III.

Special Characters.—In view of the number of hybrids which are cultivated, the distinction of the various commercial cinchona

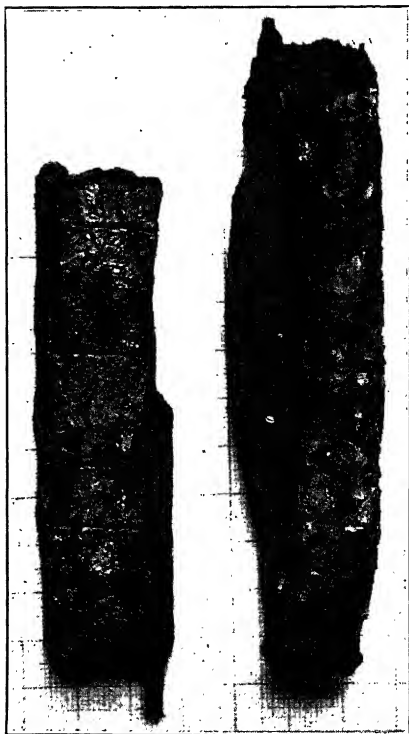


FIG. 207.—Bark of *Cinchona Calisaya* (Newman).

barks is a matter of some difficulty, a fact which is appreciated by examiners who may be relied upon to provide typical specimens for identification. Students are, however,

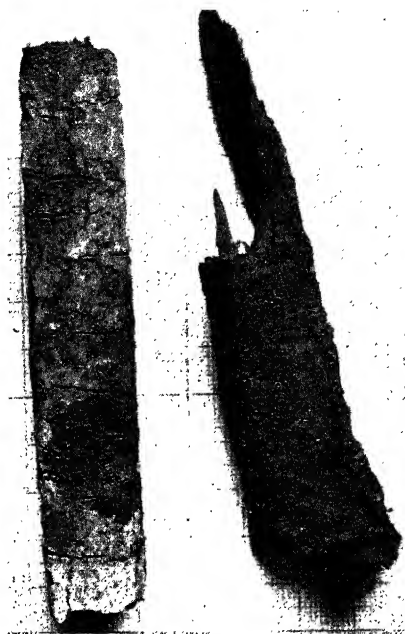


FIG. 208.—Bark of *Cinchona Ledgeriana* (Newman).

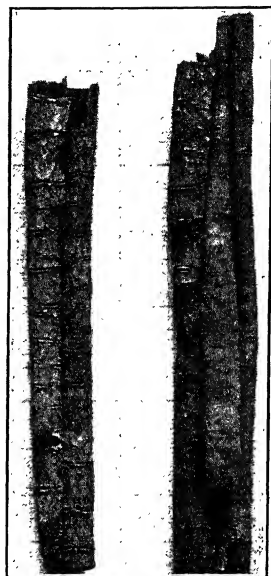


FIG. 209.—Bark of *Cinchona officinalis* (Newman).

urged to examine as many different samples as possible of each variety of bark since all are not equally typical. The following notes on four important species have been made as concise as possible to facilitate comparison :—

<i>C. succirubra</i> , Fig. 206.	<i>C. Calisaya</i> , Fig. 207.	<i>C. Ledgeriana</i> , Fig. 208.	<i>C. officinalis</i> , Fig. 209.
Frequently 20 to 40 mm. in diameter, and 2 to 6 mm. thick. Well marked longitudinal wrinkles, relatively few transverse cracks. Some pieces, but by no means all, show reddish warts.	12 to 25 mm. or more in diameter, and 2 to 5 mm. thick. Broad longitudinal fissures; transverse cracks about 6 to 12 mm. apart.	Similar to <i>Calisaya</i> . Similar to <i>Calisaya</i> , but cracks more numerous and less deep. Some pieces show longitudinal wrinkles and reddish warts.	Up to 12 mm. in diameter, and 1.5 mm. thick. Transverse cracks very numerous, often less than 6 mm. apart.
Powder reddish-brown.	Powder cinnamon-brown.	Powder cinnamon-brown.	Powder yellowish.

Confirmation may be obtained by microscopical examination, measurements being made of the secretion tubes and bast fibres.*

	Secretion Tubes.		Bast Fibres.		
	Radial Measurement.	Tangential Measurement.	Radial Measurement.	Tangential Measurement.	Length.
<i>C. succirubra</i> ..	74-115 μ	100-365 μ	50-105 μ	30-65 μ	352-1470 μ
<i>C. Calisaya</i> ..	40-86 μ	47-137 μ	21-95 μ	20-85 μ	372-1060 μ
<i>C. Ledgeriana</i> ..	43-85 μ	75-128 μ	30-75 μ	40-75 μ	485-850 μ
<i>C. officinalis</i> ..	25 μ	42 μ	30-75 μ	30-65 μ	480-890 μ

Constituents.—The most important constituents of cinchona are the crystalline alkaloids quinine (Pelletier and Caventou, 1820), quinidine (Henry and Delondre, 1833), cinchonidine, and cinchonine.† A large number of alkaloids of lesser importance have been isolated. Some of these, *e.g.* quinicine and cinchonicine, are amorphous. The amount of alkaloids present and their ratios to one another vary considerably in the different species and hybrids and also according to the environment of the tree and the age and method of collection of the bark. The official drug is required to contain not less than 6 per cent. of total alkaloids, of which not less than one-half consists of quinine and cinchonidine. Typical analyses of important barks are as follows :—

	<i>C. succirubra.</i>	<i>C. Calisaya.</i>	<i>C. Ledgeriana.</i>	<i>C. officinalis.</i>	<i>C. robusta.</i>
Quinine ..	per cent. 0.82-1.37	per cent. 0.0-4.0	per cent. 4-13	per cent. 1.74-7.52	per cent. 1.09-7.72
Cinchonidine	3.20-5.13	0.0-2.0	0.0-3.4	0.0-3.13	2.63-8.46
Cinchonine	1.76-2.46	0.3-2.0	0.0-1.5	} 0.15-2.44	0.43-5.58
Amorphous Alkaloids	0.27-1.87	—	0.2-2.0		
Quinidine ..	none	0.0-3.0	none ‡	0.0-0.28	none

The alkaloids appear to be present in the parenchymatous tissues of the bark in combination with quinic acid and cinchotannic acid. Quinic acid, $C_7H_{12}O_6$, is present to the extent of 5 to 8 per cent. Cinchotannic acid is a phlobatannin

* The following figures refer to stem barks only. For details of root barks and the stem barks of other species and hybrids, see Tschirch's *Handbuch der Pharmakognosie*.

† For an account of the chemistry of these alkaloids see Bentley and Driver's *Text Book of Pharmaceutical Chemistry*, pp. 520 to 522.

‡ 0.1 to 0.8 per cent. in the root bark.

and a considerable amount of its decomposition product, "cinchona red," is also found in the bark. Other constituents are "quinovin" (up to 2 per cent.), which is of glycosidal nature, a small amount of quinovic acid, $C_{30}H_{48}O_6$, starch, and calcium oxalate.

Chemical Tests.—Students should carry out the official tests for identity of quinine sulphate and quinidine sulphate. The colour reaction using bromine and ammonia is known as the thalleioquin test. The fact that quinine and cinchonidine form sparingly soluble tartrates is made use of in the official assay of the bark. The following summary may be found useful :—

Quinine. Quinidine. Cinchonine. Cinchonidine.

<i>Formula</i> ..	$C_{20}H_{24}O_2N_2$	$C_{19}H_{22}ON_2$
<i>Form</i> ..	Hydrated crystals	Anhydrous crystals
<i>Acid solution</i> ..	Fluorescent	Non-fluorescent
<i>Thalleioquin test</i>	Positive	Negative
<i>Solubility in ether</i>	Readily	Almost insol.
<i>Rotation of alcoholic solution</i>	Sparingly	Sparingly
	+ve	+ve

Allied Drugs.—The barks of certain species of *Remijia* (Rubiaceæ) contain alkaloids. The bark of *R. pedunculata* was formerly used for the preparation of quinine, but it is now unobtainable. It also contains cupreine, an alkaloid which responds to the thalleioquin test and by methylation forms quinine. False cuprea bark (*R. Purdiana*) contains no quinine but an alkaloid cusconidine and small proportions of cinchonine and cinchonamine.

Uses.—Galenicals of cinchona are used as bitter tonics and stomachics. On account of the astringent action a decoction and acid infusion are sometimes used in gargles. Quinine and totaquine are widely employed, particularly for malaria. For details, see the British Pharmaceutical Codex.

IPECACUANHÆ RADIX

Ipecacuanha, B.P.; *Ipecacuanha Root*, Rio, Brazilian, or Johore *Ipecacuanha*; F. *Ipecacuanha Annellée*, Racine Brésilienne; G. Ruhrwurz, Brechwurzel

Source.—*Ipecacuanha* is the dried root of *Cephaelis Ipecacuanha* (Brot) A. Rich. (*Psychotria Ipecacuanha* Stokes, *Uragoga*

Ipecacuanha Baillon), a shrub 20 to 40 cm. in height. The plant is found over a large area in Brazil, particularly in the moist and shady forests of Matto Grosso and Minas Geraes. It is successfully cultivated in the State of Selangor, near Singapore. Collection has also been attempted in India, Java, China, and Tanganyika.

History.—What appears to have been *ipecacuanha* was mentioned, under the name of *Igpecaya*, by a Portuguese friar about 1600. The drug was introduced into Europe in 1672.

Collection and Preparation.—Weddell observed the collection of the drug about 1849. His description is abstracted in the Pharmacographia in the following words:—

“ The *ipecacuanha* plant, *Poaya* of the Brazilians, grows in valleys, yet prefers spots which are rather too much raised to be inundated or swampy. Here it is found under the thick shade of ancient trees growing mostly in clumps. In collecting the root, the *poayero*,* for so the collector of *poaya* is called, grasps in one handful if he can, all the stems of a clump, pushing under it obliquely into the soil a pointed stick to which he gives a see-saw motion. A lump of earth enclosing the roots is thus raised; and, if the operation has been well performed, those of the whole clump are got up almost unbroken. The *poayero* shakes off adhering soil, places the roots in a large bag which he carries with him, and goes on to seek other clumps. A good collector may thus get as much as 30 lb. of roots in a day; but generally a daily gathering does not exceed 10 or 12 lb., and there are many who scarcely get 6 or 8 lb. In the rainy season, the ground being lighter, the roots are removed more easily than in dry weather. The *poayeros*, who work in a sort of partnership, assemble in the evening, unite their gatherings, which, having been weighed, are spread out to dry. Rapid drying is advantageous; the root is therefore exposed to sunshine as much as possible, and if the weather is favourable, it becomes dry in two or three days. But it has always to be placed under cover at night on account of the dew. When quite dry, it is broken into fragments, and shaken in a sieve in order to separate adherent sand and earth, and finally it is packed in bales for transport.

“ The harvest goes on all the year round, but is relaxed a little during the rains, on account of the difficulty of drying the produce. As fragments of the root grow most readily, complete extirpation of the plant in any one locality does not seem probable. The more intelligent *poayeros* of Matto Grosso are indeed wise enough intentionally to leave small bits of root in the place whence a clump has been dug, and even to close over the opening in the soil.”

Much of the drug passes down the Parana and Paraguay Rivers and is exported from Montevideo, but some is also exported from Rio de Janeiro, Bahia, and Pernambuco.

* Tschirch, *Handbuch der Pharmakognosie*, III, 1, 686, Fig. 176, shows *poayeros* at work.

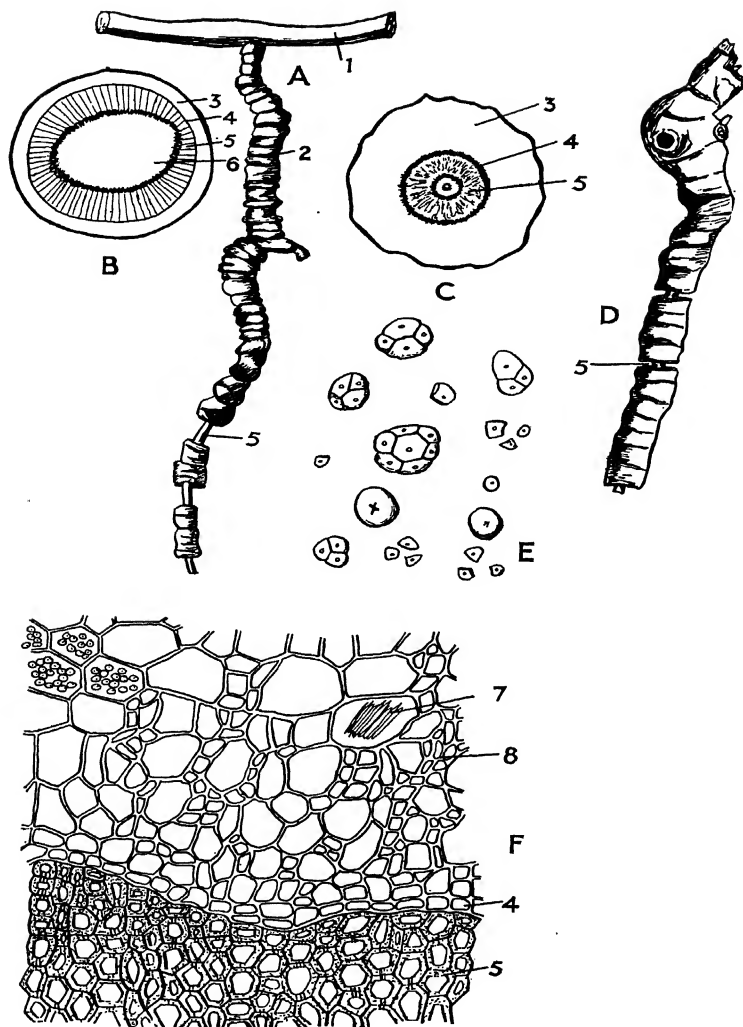


FIG. 210.—Ipecacuanha. A, rhizome and root of *Rio ipecacuanha*; B, transverse section of the rhizome; C, transverse section of the root; D, *Cartagena ipecacuanha*; E, starch of official *ipecacuanha*; F, portion of a transverse section of the same. 1, rhizome; 2, root; 3, bark; 4, cambium; 5, wood; 6, pith; 7, calcium oxalate; 8, phloem. (A to C after Tschirch; E and F after Gilg.)

Ipecacuanha was introduced into India in 1866, but the best results have been obtained in the Malay States, the drug from which is known as Johore ipecacuanha.

Macroscopical Characters.—The underground portion consists of thin, horizontal rhizomes from the lower surface of which roots are given off. Some of the latter remain thin, whilst others develop an abnormally thick bark and become annulated. It is almost impossible to collect the roots without a certain amount of these subterranean stems or rhizomes, and the Pharmacopœia permits the use of a drug containing not more than 5 per cent. of stems.

The drug occurs in tortuous pieces up to 15 cm. in length and 6 mm. in diameter, but it is usually smaller. The colour of the outer surface varies from a deep brick-red to a very dark brown, the colour being very largely dependent on the type of soil in which the plant has been grown. Most of the roots are more or less annulated externally, and some have a portion of the rhizome attached (Fig. 210, A), while separate portions of rhizome and non-annulated roots are also found. Speaking generally, the drug of present-day commerce is less markedly annulated than was formerly the case, a fact which points to earlier collection. The ridges are rounded and completely encircle the root; here and there the bark has completely separated from the wood (Fig. 210, A, 5).

The root breaks with a short fracture and shows a thick, greyish bark and a small, dense wood, but no pith. The rhizomes, on the other hand, have a much thinner bark and a definite pith (Fig. 210, B). The drug has little odour, but is irritating and sternutatory when in fine powder, and has a bitter taste.

Microscopical Characters.—A transverse section of the root shows a thin, brown cork, the cells of which contain brown, granular material. Below this is an exceptionally wide secondary cortex, the cells of which are parenchymatous and contain starch, usually in compound grains with from two to eight components, or raphides of calcium oxalate. The bast ring contains no sclerenchymatous cells or fibres. The wood consists of substitute fibres (containing starch), fibres, tracheids, and small tracheidal vessels (without starch). For powder, see p. 109.

The stems have sclerenchymatous cells in the pericycle and spiral vessels in the protoxylem. Those which have been exposed to light contain chlorophyll.

Allied Drug.—*Cartagena ipecacuanha* (Fig. 210, D) is exported from Cartagena and Savanilla. Together with Rio ipecacuanha it is official in the U.S. Pharmacopœia. There is much in favour of Humboldt's view that the differences between the Rio and Cartagena plants are merely due to geographical variation. The Cartagena plant is, however, frequently regarded as a distinct species, *Cephælis* (*Uragoga*) *acuminata* Karsten (*U. granatensis* Baillon). The main differences between the two drugs are tabulated below:—

	<i>Rio Ipecacuanha.</i>	<i>Cartagena Ipecacuanha.</i>
<i>Usual diameter</i>	1 to 4 mm.	4 to 6.5 mm.
<i>Colour</i> ..	Brick-red to brown	Greyish-brown
<i>Annulations</i> ..	Very crowded	Less crowded and less projecting
<i>Starch</i>	Compound grains up to 24μ	Compound grains up to 35μ

Ipecacuanha stems, although containing the same alkaloids as the roots, usually contain them in smaller proportion. An excessive amount of stem must, therefore, be regarded as an adulteration.

Adulterants.—At one time other “ipecacuanhas” were regularly imported, the name being applied in South America to a number of different roots which were reputed to have emetic properties. Most of these are very easily distinguished from the genuine drug and are now rarely imported. As none of the following contain emetine the following brief notes and a test for emetine are amply sufficient to distinguish them from the official drug.

<i>Name.</i>	<i>Source.</i>	<i>Remarks.</i>
Undulated Ipecacuanha	<i>Richardsonia scabra</i> (Rubiaceæ).	Bark often violet; very starchy; wood porous, containing vessels; raphides very numerous.
Lesser Striated Ipecacuanha	<i>Manettia ignita</i> (Rubiaceæ).	Violet, starchy bark; porous wood.
Greater Striated Ipecacuanha	<i>Psychotria emetica</i> (Rubiaceæ).	Longitudinally striated; bark violet; starch absent; wood non-porous.
White Ipecacuanha ..	<i>Ionidium Ipecacuanha</i> (Violaceæ)	Bark very thin; wood porous; starch absent.
East Indian Root ..	<i>Cryptocoryne spiralis</i> (Araceæ).	Structure monocotyledonous.

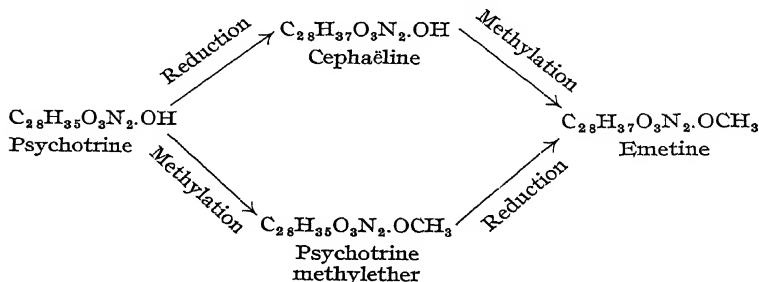
Test for Emetine.—Mix 0.5 G. of the powdered drug with 20 ml. of hydrochloric acid and 5 ml. of water; filter, and to 2 ml. of the filtrate add 0.01 G. of potassium chlorate. If emetine is present a yellow colour appears, which, on standing for about one hour, gradually changes to red.

Constituents.—Ipecacuanha contains the alkaloids emetine (Pelletier and Magendie, 1817), cephaëline (Paul and Cownley, 1894), psychotrine, psychotrine methyl ether, and emetamine. The drug also contains a crystalline glycoside (ipecacuanhin), ipecacuanhic acid (see p. 673), starch, and calcium oxalate.

Typical analyses are as follows :—

	<i>Total Alkaloids, per cent.</i>	<i>Emetine, per cent.</i>	<i>Cephaëline, per cent.</i>	<i>Ash, per cent.</i>
Rio (Matto Grosso)	2.73	1.98	0.50	3.34
Rio (Bahia) ..	2.19	1.36	0.63	3.21
Johore	2.45	1.46	0.62	2.93
Rhizome	1.80	1.18	0.59	—
Cartagena ..	2.75	1.47	1.39	6.02

The British Pharmacopœia requires the drug to contain not less than 2 per cent. of total alkaloids, calculated as emetine, of which not less than two-thirds consists of non-phenolic alkaloids. As may be seen from the following scheme, the alkaloids are closely related to one another, and emetine and psychotrine methylether are non-phenolic :—



Emetine, which is the alkaloid usually required in medicine, may thus be prepared by methylating the cephaëline originally present in the drug.

Uses.—Ipecacuanha is used as an expectorant and emetic and in the treatment of amoebic dysentery. Emetine has a more expectorant and less emetic action than cephaeline, a fact which accounts for the exclusion of the Cartagena drug from the British Pharmacopœia. In the treatment of amoebic dysentery emetine hydrochloride is frequently given by injection, and emetine and bismuth iodide by mouth.



FIG. 211.—Gambier Factory, Singapore. (From Kew Gardens Collection).

CATECHU

Catechu, B.P.; *Pale Catechu*, Gambir, Gambier; F. *Cachou Clair*, Gambir Cubique; G. *Gelbes Katechu*, Gambir-Katechu

Source.—Gambir or pale catechu is a dried, aqueous extract prepared from the leaves and young twigs of a climbing shrub, *Uncaria gambier* (Hunter) Roxb. It must be carefully distinguished from black catechu or cutch (see p. 620). The plant is a native of Malaya, and it is largely cultivated for the production of the drug in the Dutch East Indies (Java, Sumatra, and Borneo) and in the Straits Settlements (Johore and Pahang). It is no longer cultivated in Singapore.

History.—The catechu described by Barbosa (1514) was black catechu or cutch, and the first account of gambir appears to be that of a Dutch trader in 1780. In addition to the cube gambir used in pharmacy, large blocks of the extract are imported for use in dyeing and tanning. Several other forms are used in the East for chewing with betel leaf.

Collection and Preparation.—The preparation of catechu in Johore has recently been described by Roebuck,* and differs only slightly from the procedure adopted in the Dutch East Indies. The industry is in the hands of the Chinese or natives. The shrubs are grown from seed either as a separate crop or as a "catch" crop with rubber or derris. The plants are arranged about 10 feet apart, and when about 6 feet high, *i.e.* in about two years, the young leafy twigs about 50 cm. long are cut off. Cutting is practised about every 4 or 6 months,

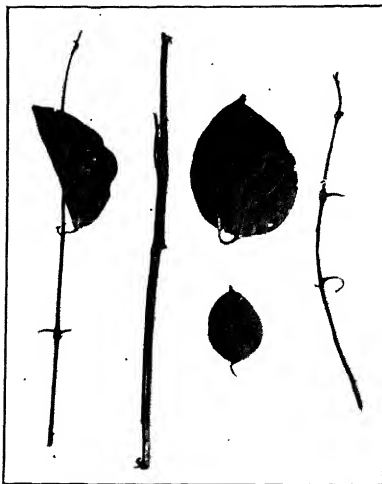


FIG. 212.—Leaves and twigs of *Uncaria gambier* (Sutcliffe).

and well-cared-for plants will produce a satisfactory crop for ten years or more. The leaves and twigs are carried to a palm-thatched "factory" and any old woody portions rejected, whilst the leaves and young twigs are thrown into a large pan which is about three-quarters full of boiling water. The pan observed by Roebuck had an iron bottom, but in the Dutch Indies both cast iron and copper pans are said to be used. The pan is heated by a wood fire and is fitted with a deep wooden rim (Fig. 213). The material is boiled for three hours and is frequently stirred and bruised with long, four-pronged wooden forks (Fig.

* Roebuck, *Malayan Gambir*, P.J., 1936, Jan., 68. We are indebted to Mr. T. Roebuck, Ph.C., for specimens of the leaves and twigs of *Uncaria gambier*, shown in Fig. 212, samples of the drug, and for the photographs reproduced in Figs. 213 and 214; also for a copy of a Dutch article describing the preparation of the drug in the Dutch East Indies. For an earlier account of catechu manufacture, see the *Pharmacographia* and P.J., 1892, June, 1003.

214). The marc is then lifted with three-pronged wooden forks to a large trough made from a hollowed-out tree trunk and is pressed and washed, the washings running into the pan. The liquid is then evaporated for about two and a half hours, when it becomes yellowish-green and somewhat pasty.* The liquid is transferred to small wooden tubs, and crystallisation is induced by cooling in water and stirring with

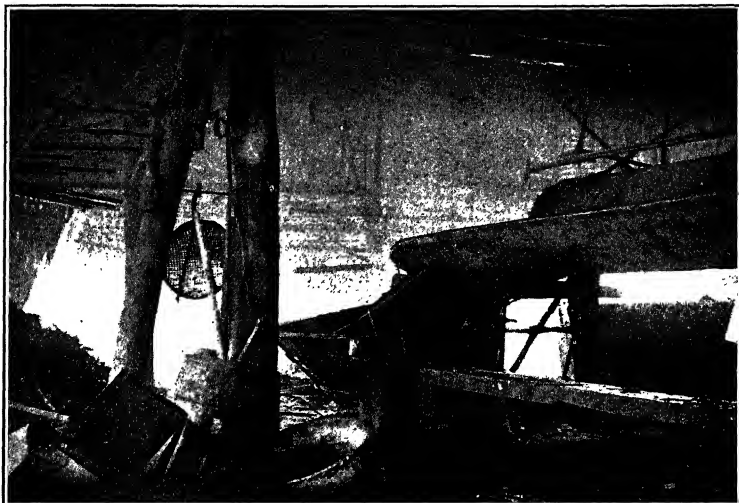


FIG. 213.—Interior of catechu "factory" in Johore (Roebuck).

a cylindrical piece of wood, the surface of which is kept free from crystals by rubbing with the fingers. After about ten minutes the product becomes pasty and is poured into matting, kerosene tins, or shallow trays.

In the Dutch East Indies the wooden sides of the tray are fastened by pins to a slightly larger table covered with coarse

* The above details apply more particularly to the Chinese workers. The natives of the Dutch East Indies often pack the leaves in nets, boil and steam them, press in a primitive press made from a split tree trunk, to which pressure is applied by driving in wedges and thus obtain a concentrated extract which requires no evaporation. The partly exhausted marc is again boiled and pressed, and the liquid obtained used for boiling and steaming the next net full of leaves.

cloth, which forms the base of the tray. The sides are divided by saw cuts on their surface. The moist catechu mass is poured in and some of the water filters through the cloth. When sufficiently hard, the sides are removed and the mass cut into cubes by means of a string along the marks made by the saw cuts. The cubes are finally dried for about a fortnight in the sun.



FIG. 214.—Material and apparatus used in the manufacture of catechu in Johore (Roebuck).

Many different forms of catechu are used in the East, and the drug for the Eastern market frequently has from 20 to 60 per cent. of fine rice husks added as the liquid coagulates in the tubs. Such catechu is, of course, unofficial, as it contains abundant starch.

Macroscopical Characters.—Catechu occurs in cubes, which are very friable and may be broken in transit or, if incompletely dried, may be more or less agglutinated. The Pharmacopœia describes the colour of the external surface as greyish-brown to dark reddish-brown and the edges of the cubes as measuring about 25 mm. Of the samples in our possession

those from the Dutch East Indies measure 17 to 22 mm. and have a reddish-brown surface, often stamped with a maker's mark, whilst those from Johore measure 24 to 29 mm., have a blackish exterior and the faces of the cube are depressed. Internally, both varieties are cinnamon-brown and porous. Odourless; taste, very astringent and at first somewhat bitter, afterwards sweetish.

Microscopical Characters.—When mounted in water, catechu shows minute, acicular crystals of catechin, many of which are branched and interlacing. They dissolve on warming and a considerable amount of vegetable debris is left. The latter may be examined by treating the powder with successive quantities of cold water or alcohol, and mounting portions of the residual debris in chloral iodine, chloral hydrate, and phloroglucinol and hydrochloric acid. The microscopical investigation of catechu and the leaves and twigs from which it is prepared appears to require further investigation.* The leaves, particularly the stipules, bear simple, unicellular hairs up to about 350μ in length, with smooth, moderately thick, lignified walls. The twigs have lignified pericyclic fibres, wood fibres, and spiral, annular and pitted vessels. Minute starch grains are commonly present, particularly in the Dutch drug, but the amount is strictly limited by the official description. Rice husks have been observed in some samples, but whether they are found in few or many commercial samples still requires to be settled. Any observations on this point would be welcomed.†

Chemical Tests.—(i) *For Gambir-Fluorescin.* Extract a little of the powdered drug with alcohol and filter. To the filtrate add solution of sodium hydroxide. After shaking, add a few millilitres of light petroleum, shake again, and allow to stand. The petroleum spirit layer shows a strong green fluorescence.

(ii) *For Chlorophyll.* Gently warm a little powdered gambir with chloroform, shake, and filter. If the extract contains sufficient chlorophyll a green colour is developed, but with many samples the test is inconclusive.

(iii) *For Catechin.* See p. 673. This is a modification of the usual test for lignin. Phloroglucinol is formed from catechin, and with hydrochloric acid turns the match-stick red.

* One of my former students, Mr. H. G. Thompson, Ph.C., commenced this investigation, but has not yet been able to complete it. The following notes are mainly based on his work.

† Rice husks are figured in Greenish's *Food and Drugs*, p. 350.

Constituents.—Gambir contains about 7 to 20 per cent. of catechins, 33 to 47 per cent. of catechutannic acid, catechu red, quercitin, and gambir-fluorescin. It should not lose more than 10 per cent. of its weight on drying, but samples have occasionally been found containing as much as 20 per cent. of water. If of good quality the water-insoluble matter should not exceed 25 per cent. Ash 1.6 to 5.3 per cent.

Catechin forms white, acicular crystals of the formula $C_{15}H_{14}O_6, 4H_2O$. Catechutannic acid is an amorphous phlobatannin which appears to be formed from catechin by loss of the elements of water. It readily yields the phlobaphene, catechu-red. If the drug is carefully prepared it will contain a high proportion of catechin and correspondingly smaller amounts of catechutannic acid and catechu-red.

Allied Drug.—*Cutch* or *Black Catechu* is an extract prepared from the heartwood of *Acacia Catechu* (Fam. Leguminosæ). The trees are felled and the heartwood is cut into chips and boiled with water. The decoction is strained and evaporated in iron vessels to a thick syrup. This is poured on leaves or paper and allowed to solidify. It is then broken up and exported.

Cutch occurs in black, somewhat porous masses. The taste resembles that of gambir. Microscopical examination of the water-insoluble residue shows wood fibres and large vessels, and sometimes fragments derived from the leaves on which the drug is spread.

Cutch contains from 2 to 12 per cent. of catechins, 25 to 33 per cent. of phlobatannin, 20 to 30 per cent. of gummy matter, quercitrin, quercitin, moisture, etc. It yields from 2 to 3 per cent. of ash. The catechin (acacatechin) is not identical with that found in gambir.

The drug may be distinguished from gambir by the fact that it gives no reaction for chlorophyll or for gambir-fluorescin.

Uses.—Gambir is used in medicine as an astringent. Most of the gambir imported, and practically the whole of the cutch, are used in dyeing and tanning.

Family **CAPRIFOLIACEÆ**

The Caprifoliaceæ comprises 11 genera and about 340 species. Of the British members may be mentioned *Sambucus nigra* and *Viburnum Opulus* (guelder rose), which have regular

flowers, and species of *Lonicera* (honeysuckle), which have zygomorphic ones. The occurrence of valerianic acid in various species of *Sambucus* and *Viburnum* is of interest in view of the close relationship between this family and the Valerianaceæ.

Sambucus.—*Elder Flowers.*—The drug consists of the fresh or dried corollas and stamens of *Sambucus nigra*. The flowers are white, about 3 mm. in diameter and have the formula $K_5, C(5), A_5$ epipetalous, $G(3)$. A few hours after collection the corollas become loosened and are separated by sifting. They have a characteristic odour due to a small amount of volatile oil, and a slightly bitter taste. They are used for making elder-flower ointment. The bark and leaves, the latter containing a cyanogenetic glycoside (sambunigrin), an alkaloid and a purgative resin, are also used in medicine.

VIBURNI PRUNIFOLII CORTEX

Viburnum; *Black Haw Bark*; *F. Écorce d'Aubépine Noire*; *G. Amerikanische Schneeballenrinde*

Source.—Black haw is the bark of *Viburnum prunifolium*, a shrub or tree about 8 metres in height, which is found in the eastern and central U.S.A. Most of the drug is collected in western North Carolina.

Characters.—Root bark is said to be most active, but the commercial drug is usually a mixture of the bark from the root, stem, and branches. The root bark frequently bears small roots, whilst the stem bark may be identified by the presence of lenticels.

The bark occurs in curved pieces or quills about 2 to 6 cm. long, 1 to 3 cm. wide, and 1 to 3 mm. thick. The outer surface is greyish-brown to reddish-brown, longitudinally wrinkled or, in old barks, fissured and scaly. The inner surface is reddish-brown and striated. Odour, slightly valerianaceous; taste, bitter and astringent.

Microscopical examination shows numerous groups of sclerenchymatous cells, but no fibres. Rosette crystals of calcium oxalate are abundant.

Constituents.—*Viburnum* contains viburnin (a resin-like, bitter principle), tannin, and organic acids (valerianic, malic, and oxalic).

Uses.—*Viburnum* has been used for asthma, dysmenorrhœa, and as a uterine sedative. Clinical reports are not very favourable and the drug is no longer official.

Family VALERIANACEÆ

The Valerianaceæ includes 10 genera and about 350 species, most of which are herbs. The British species comprise a number of species of *Valeriana* and *Valerianella*, whose flowers have three stamens, and *Centranthus ruber* (red valerian), whose flowers have only one stamen.

VALERIANÆ RHIZOMA

Valeriana, B.P., *Valerianæ Radix*; *Valerian Rhizome*, *Valerian Root*; F. *Racine de Valériane*; G. *Baldrianwurzel*, *Katzenwurz*

Source.—Valerian consists of the dried rhizome and roots of *Valeriana officinalis*, a perennial plant about 1 to 2 metres in height. It is obtained from wild and cultivated plants in England, Holland, Belgium, France, Germany, and Japan. It is also cultivated in the U.S.A. In England both the var. *mikanii* and the var. *sambucifolia* appear to be cultivated, whilst the Continental drug is mainly obtained from the var. *sambucifolia* and a var. *latifolia* Vahl (*V. excelsa* Poir).

Valerian root of excellent quality, but concerning which little is known, is now being imported from the U.S.S.R.

The two varieties of *Valeriana officinalis* found in Britain may be distinguished by the following characters:—

Var. *sambucifolia* Mikanii fil.

Var. *mikanii* Syme.

Found in damp copses and by the sides of streams.
Cats not attracted.

Usually five or six pairs of leaflets.
Leaflets relatively broad and serrated on both margins.

Found on stiff slaty or calcareous soils.
Cats strongly attracted and scratch up the roots.
Six to ten pairs of leaflets.
Leaflets longer and narrower and usually serrated on the posterior margin only.

Cultivation, Collection, and Preparation.—Both of the English varieties of the plant are common in Derbyshire and are

cultivated to a limited extent in that county and in other parts of England. The plants are not grown from seed, the ground being stocked by collecting wild plants. In subsequent years, when the old plants are dug up, the young plants developing on the stolons (Fig. 215) may be replanted. The plants are grown on well-manured land and, since they require plenty of moisture, are often grown near streams. As the flowering stems appear they are cut off to avoid exhaustion of the rhizome. In September or early October the tops are cut off with a scythe and the rhizomes dug up. The washing and drying processes, as described by Upsher Smith,* are as follows:—

“ A stout plank was placed across the stream and a large wooden box was secured on one side of it by means of two strong stakes driven into the bed of the stream. The box was perforated with holes and partially filled with the rhizomes, to which damp earth freely adhered owing to the wet season. The water flowed through the box, the depth being about 2 feet to $2\frac{1}{2}$ feet, and the cleansing was facilitated by stirring the rhizomes with a rake.

“ The final operation consisted in drying the wet rhizomes. For this purpose a large shed was floored about 6 feet from the ground, the flooring being well perforated, and then strewn with the rhizomes. In the room beneath a large coke stove was set going, and the heating continued until the drying process was complete.”

History.—The word *Valeriana* is first met with in writings of the ninth and tenth centuries. The drug is mentioned in Anglo-Saxon works of the eleventh century and was much esteemed not only for its medicinal properties but as a spice and perfume. Spikenard ointment, which was used by the Romans and has long been used in the East, was prepared from the young shoots of the valerianaceous plant, *Nardstachys jatamansi*.

Macroscopical Characters.—The drug consists of yellowish-brown rhizomes, stolons, and roots. The rhizomes are erect, 2 to 4 cm. in length, and 1 to 2.5 cm. wide, and may be entire or sliced. The roots, which are up to 10 cm. in length and 2 mm. in diameter, are more or less matted and broken. In some samples of the drug they almost completely envelop the rhizome, whilst in others they are mainly separated from it. The drug breaks with a short and horny fracture and is whitish or yellowish internally. The fresh drug is odourless, but it rapidly develops its characteristic valerianaceous odour on drying. The taste is camphoraceous and slightly bitter.

* Upsher Smith, *P.J.*, 1904, 701.

Microscopical Characters.—A transverse section of the rhizome shows a thin periderm, a large parenchymatous cortex which is rich in starch, and an endodermis containing globules of volatile oil. Within a ring of collateral vascular bundles

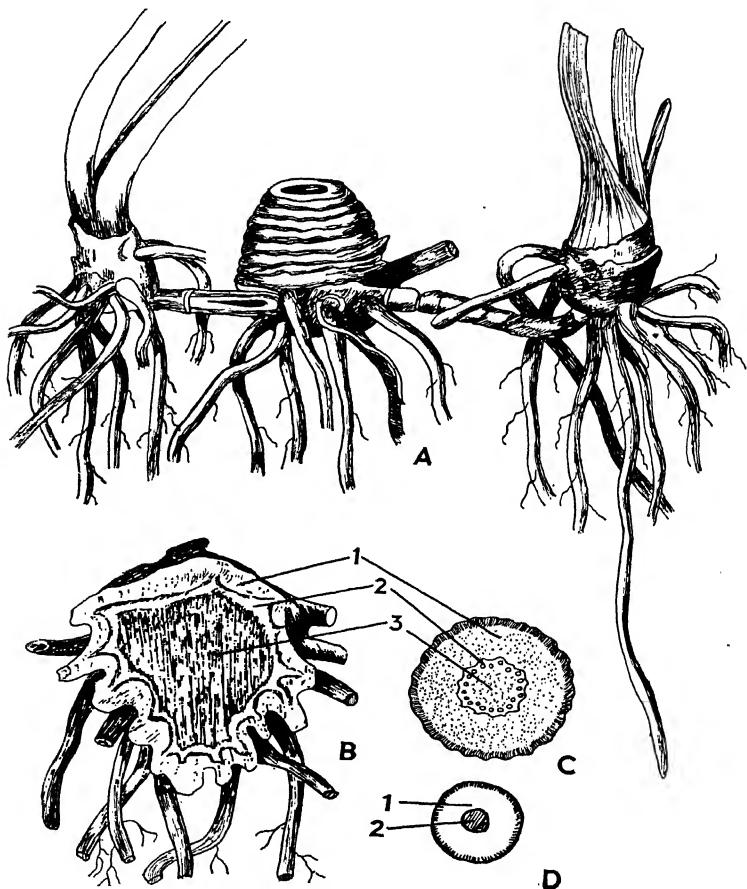


FIG. 215.—*Valeriana officinalis*. A, rootstock with two stolons; B, longitudinal section of rhizome; C, transverse section of stolon; D, transverse section of young root. 1, bark; 2, wood; 3, pith. (A after Tschirch and Oesterle, B to D after Gilg.)

lies a large pith containing scattered groups of sclerenchymatous cells.

A transverse section of a root shows an epidermis bearing papillæ and root hairs, and an exodermis containing globules of oil. The cortex and pith, the latter well developed in old roots, contain starch. The starch is present mainly in compound grains with two to four components, measuring 3 to 20 μ in diameter.

Constituents.—Valerian yields about 0.5 to 1.0 per cent. of volatile oil. This contains esters (bornyl *isovalerianate*, bornyl acetate, bornyl formate), alcohols, terpenes, and a sesquiterpene. The development of the odour on drying is due to the hydrolysis of the esters and the production of free *isovalerianic acid*. The presence of the alkaloids chatinine and valerine, reported by Chevalier (1907), has been confirmed by Goris and Vischniac (1921). Chevalier also found a glycoside and resin.

Allied Drugs.—*Indian valerian* consists of the dried rhizomes and roots of *Valeriana Wallichii*. The drug, which was official in the 1914 Pharmacopœia, is collected in the Himalayas. The rhizomes are dark brown in colour, about 5 cm. long and 6 to 10 mm. in diameter. Indian valerian yields 0.3 to 1.0 per cent. of volatile oil, which contains esters of *isovalerianic* and formic acids.*

Japanese valerian or *kesso* is obtained from *Valeriana angustifolia*. It yields as much as 8 per cent. of volatile oil, which is, however, not identical with the oil from the European drug.

Uses.—Valerian is used as a carminative and antispasmodic in hysteria, shell-shock, and other nervous disorders.

Order CAMPANULALES

The order Campanulales includes the Campanulaceæ and Compositæ. In these families the anthers are in contact with one another or are fused so as to form a tube into which the pollen is shed. The flowers are hermaphrodite, or unisexual, by suppression.

Family CAMPANULACEÆ

The family consists of 61 genera and about 1,500 species, mainly annual or perennial herbs or undershrubs. The most important of the three subfamilies are :

* See Bullock, *P. J.*, 1925, Aug. 1, 122; *Y. B. Pharm.*, 1926, 493.

Subfamily *Campanuloideæ*. Flowers regular, generally with free anthers, *e.g. Campanula*.

Subfamily *Lobelioideæ*. Flowers zygomorphic, anthers syngenesious, *e.g. Lobelia*.

Among the anatomical characters of the family may be mentioned the presence of latex vessels and inulin, which indicate relationship with the *Compositæ*. The marginal teeth of the leaves frequently bear water pores. Calcium oxalate and glandular hairs are absent.

LOBELIÆ HERBA

Lobelia, B.P. ; *Lobelia Herb*, Indian Tobacco ; F. *Lobélie Enflée* ; G. *Lobeliakraut*

Source.—*Lobelia* consists of the dried aerial parts of *Lobelia inflata*, an annual herb indigenous to the eastern U.S.A. and Canada. It is cultivated in the States of New York, Massachusetts, and Michigan.

History.—*Lobelia* has long been used by the North American Indians. It was recommended for use in asthma by Cutler in 1813 and was introduced to the English medical profession by Reece in 1829.

Cultivation and Collection.—*Lobelia* is grown from seed which is sown either in the autumn or in March and April. The plant produces an aerial stem about 50 cm. in height. It bears alternate leaves 3 to 8 cm. in length and pale blue, bilabiate flowers. The inferior ovary develops into an inflated capsule. The plants are cut in August or September, when they bear numerous capsules. After drying, the drug is exported in bales or compressed packets. The seeds are sometimes separated by thrashing.

Macroscopical Characters.—A considerable proportion (officially not more than 60 per cent.) of the drug consists of stems. These are green or purplish, winged, and very hairy in the upper part, but becoming more rounded and channelled and less hairy below. The pale green leaves are usually more or less broken and are covered with bristly hairs. Entire leaves are ovate to ovate-lanceolate in shape. The margin is irregularly serrate-dentate and the teeth bear water pores (Fig. 216, H). The flowers are rarely seen in the drug. The

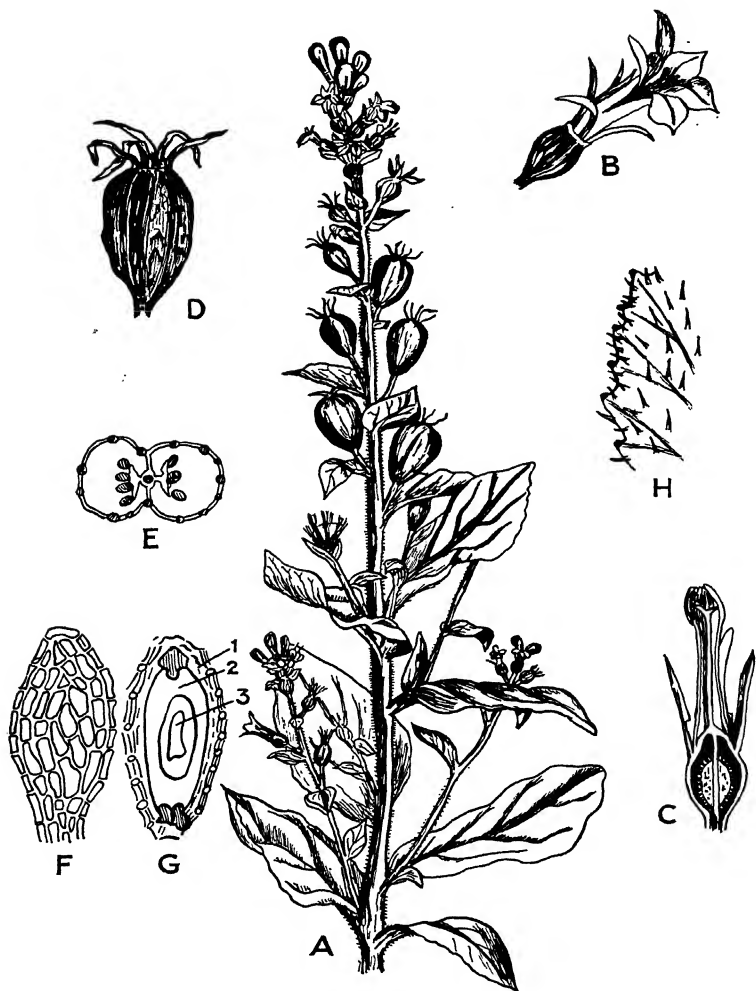


FIG. 216.—*Lobelia inflata*. A, upper part of plant; B, flower; C, flower cut vertically; D, ripe fruit; E, transverse section of fruit; F, seed; G, seed in longitudinal section; H, margin of leaf showing hairs and hydrathodes. 1, testa; 2, endosperm; 3, embryo. (A to D after Bentley and Trimen, E and G after Tschirch and Schlotterbeck, H after Gilg.)

fruits (Fig. 216, D and E) are 5 to 8 mm. in length, ribbed, and crowned by the calyx teeth. Each is bilocular and contains numerous oval-oblong, brown, reticulated seeds about 0.5 to 0.7 mm. in length. The drug has a slightly irritating odour and an acrid taste.

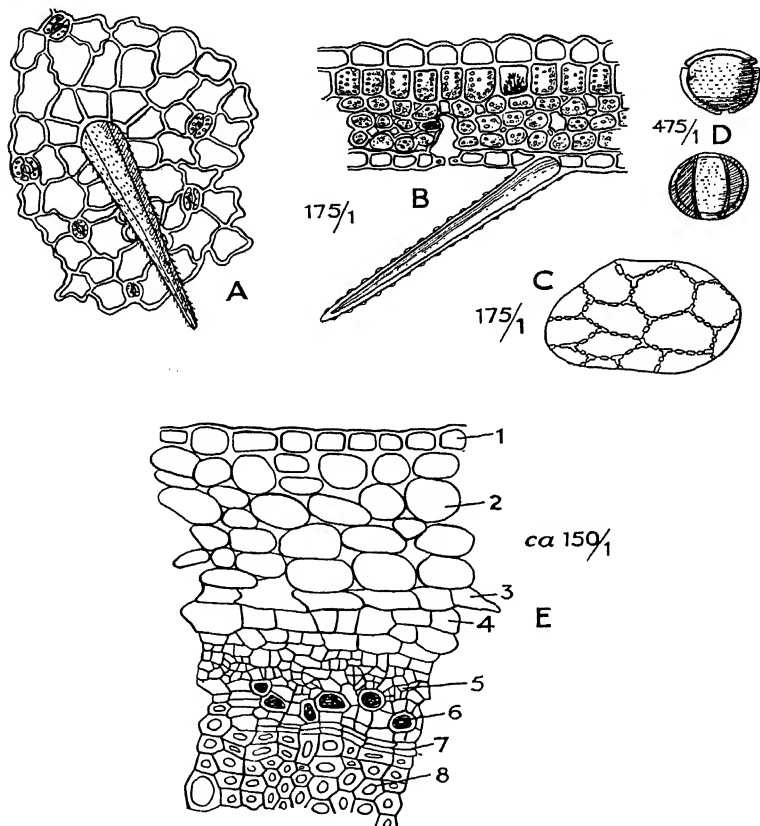


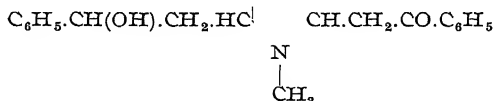
FIG. 217.—*Lobelia*. A, lower surface of leaf; B, transverse section of leaf; C, upper surface of leaf; D, pollen grains; E, transverse section of stem. 1, epidermis; 2, cortex; 3, endodermis; 4, pericycle; 5, phloem; 6, latex vessel; 7, cambium; 8, wood. (A to D after Gilg-Brandt-Schürhoff, *Lehrbuch der Pharmakognosie*, E after Greenish.)

Microscopical Characters.—The more important anatomical features of lobelia are indicated in Fig. 217. The hairs found on the leaves and stems are unicellular, conical, warty-walled, and about 1200μ long. The leaves show a papillose upper epidermis, marginal water pores, and a mesophyll containing small drops of oil.

A transverse section of the stem (Fig. 217, E) shows a well-marked endodermis and pericycle and latex vessels in the phloem. The surface of the seed (Fig. 216, F) consists of lignified, somewhat elongated polygonal cells. Characteristic pollen grains 17 to 25μ in diameter (Fig. 217, D) and fragments of the flowers may also be found. For further details, see powder, p. 105.

Constituents.—Lobelia contains about 0.25 per cent. of crystalline alkaloids. The most important of these is lobeline, which has the formula given below. Four other alkaloids, which are closely related to lobeline and are named lobelidine, lobelanine, lobelanidine, and *isolobelanine*, have been isolated.

CH₃



The drug also contains fat, resin, “inflatin,” and “lobelic acid.” It yields 8 to 12 per cent. of ash (officially not more than 5 per cent. of acid-insoluble ash).

Uses.—Lobelia is used in spasmodic asthma and chronic bronchitis. Lobeline resembles nicotine in its action on nerve cells. In large doses the drug may cause medullary paralysis.

Family COMPOSITÆ

The Compositæ is the largest family of flowering plants and comprises about 1,000 genera and 23,000 species. The main subdivisions of the family and drugs obtained from it are as follows:—

Tubulifloræ.—Latex vessels are absent, but schizogenous oil ducts are common. Corollas of disc-florets non-ligulate.

Drugs obtained from this group are : chamomiles (*Anthemis nobilis*), German chamomiles (*Matricaria Chamomilla*), insect flowers (*Chrysanthemum cinerariæfolium*), santonica (*Artemisia cina*), arnica flowers and rhizome (*Arnica montana*), calendula flowers (*Calendula officinalis*), yarrow herb (*Achillea Millefolium*), grindelia herb (*Grindelia camporum*), blessed thistle leaves (*Cnicus benedictus*), coltsfoot leaves (*Tussilago Farfara*), wormwood herb (*Artemisia Absinthium*), pellitory or pyrethrum root (*Anacyclus Pyrethrum*), elecampane root (*Inula Helenium*), and Ngai camphor (*Blumea balsamifera*).

Ligulifloræ.—Latex vessels are present and volatile oil is rare. All the flowers have ligulate corollas. Products obtained from this group are dandelion root (*Taraxacum officinale*), chicory root (*Cichorium intybus*), and lactucarium or lettuce-opium (*Lactuca virosa*).

Both clothing and glandular hairs are found in the Compositæ and, as might be expected from the size of the family, show considerable variety. The type of hair illustrated in Fig. 41, H, is, however, common.

Inulin.—As previously mentioned, inulin is commonly found in the Compositæ and Campanulacæ. It is a carbohydrate of the formula $(C_6H_{10}O_5)_n$. In the fresh plant it is dissolved in the cell sap, but in alcohol-preserved material it will be found in sphærocrystalline masses. Inulin is slightly soluble in cold water but readily dissolves in water at about 70° without gelatinising. It is precipitated from aqueous solutions by the addition of alcohol. A solution of inulin yields no blue colour on the addition of solution of iodine.

The following test for inulin and other carbohydrates (Molisch's Test) may be applied to sections or powder of drugs such as taraxacum or inula, or to the carbohydrate isolated as indicated above. Mix the substance to be tested on a white tile with a little α -naphthol and a few drops of sulphuric acid. A violet colour appears.

ANTHEMIDIS FLORES

Chamomile Flowers, Roman Chamomiles; F. Fleurs de Camomille Romaine; G. Römische Kamillen

Source.—Commercial chamomiles are the expanded flower-heads of *Anthemis nobilis*, collected from cultivated plants and dried. Chamomiles are cultivated in the south of England and in Belgium, France, and Germany. As a result of long

cultivation most of the tubular florets present in the wild plant have become ligulate and it is these "double" or "semi-double" flower-heads which form the commercial drug.

History.—Owing to the large number of similar composite plants it has proved impossible to trace the drug in classical writings. The double variety was certainly known in the eighteenth century.

Collection.—The flowers are collected in dry weather and carefully dried. The crop is often damaged by wet weather, and the discoloured flowers then obtained fetch a much lower price than those having a good colour.

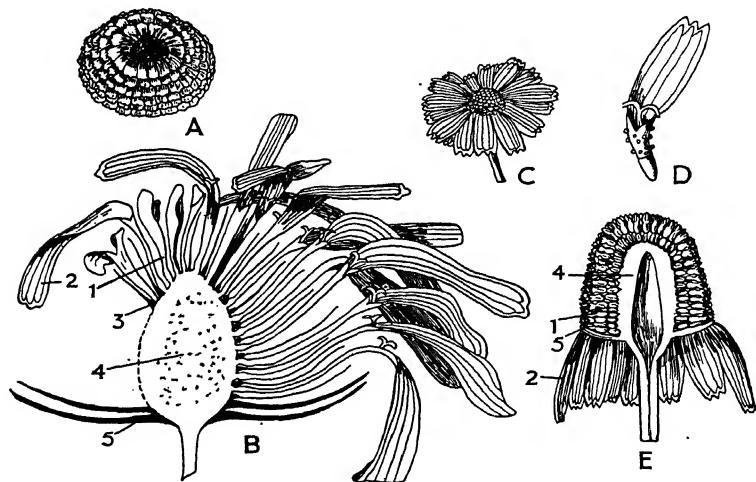


FIG. 218.—A, cultivated Roman chamomile; B, the same cut longitudinally; C, German chamomile; D, a ligulate floret of same; E, a German chamomile cut longitudinally. 1, tubular floret; 2, ligulate floret; 3, palea; 4, receptacle; 5, bract of involucre. (B after Greenish, remainder after Gilg.)

Characters.—Each dried flower-head is hemispherical and about 12 to 20 mm. in diameter. The florets are of a white to pale buff colour, the outer ones hiding the involucre of bracts. A few, hermaphrodite, tubular florets are usually found near the apex of the solid receptacle. A transition between typical tubular florets and typical ligulate ones is often seen. The ligulate florets show three teeth (or occa-

sionally two), the centre one being that most developed. There are four principal veins. The corolla is contracted near its base into a tube from which a bifid style projects. The ovary is inferior and devoid of pappus. Each floret arises in the axil of a thin membranous bract or pale, which has a blunt apex. At the base of the receptacle is an involucre consisting of two or three rows of oblong bracts which have membranous margins.

Chamomiles have a strong, aromatic odour and a bitter taste.

Allied Drugs.—The following, although somewhat resembling the wild flowers of *Anthemis nobilis*, are easily distinguished from the commercial drug.

Matricaria Chamomilla or *German chamomile flowers* (Fig. 218, C, D, and E) are small and single. The receptacle is hollow and devoid of palæ. The drug is mainly used on the Continent and in the U.S.A. It contains 0.2 to 0.36 per cent. of volatile oil.

Chrysanthemum Parthenium or *feverfew flowers* may be single or double. The receptacle is flatter than that of the Roman chamomile and may or may not bear palæ. If the latter are present they are acute and less membranous than those of the chamomile. The whole flowering tops are usually sold. Feverfew herb yields 0.07 to 0.4 per cent. of volatile oil.

Constituents.—Chamomiles contain 0.6 to 1.0 per cent. of volatile oil, a bitter principle, anthemic acid, flavone colouring matters, taraxasterol, fixed oil, etc. The oil is blue when freshly distilled but gradually becomes greenish or yellowish on keeping. It contains *isoamyl*, *isobutyl*, and other alcohols combined in the form of esters with angelic and tiglic acids, two isomeric unsaturated acids of the oleic acid series.

Uses.—Chamomiles and the volatile oil obtained from them were official in the 1914 Pharmacopœia. Considerable quantities are used in domestic medicine in the form of an infusion (for dyspepsia, etc.) or poultice.

HERBA GRINDELIAE

Grindelia ; Gum Plant ; Tar Weed ; F. *Grindelia* ;
G. *Grindelia*

Source.—The B.P.C. drug consists of the dried leaves and flowering tops of *Grindelia camporum*, whilst the U.S. National Formulary admits also a drug derived from *G. cuneifolia* and

G. squarrosa. These plants grow in the south-western U.S.A. The tops are collected and dried in the sun.

Characters.—The above species are herbaceous plants with cylindrical stems, sessile or amplexicaul leaves, and resinous flower-heads, each surrounded by an involucre of linear-lanceolate bracts. Odour balsamic; taste aromatic and bitter.

- (a) *G. camporum*.—Stems pinkish to yellowish. Leaves oblong to oblong-spathulate, up to 6 cm. long, margin irregularly serrate.
- (b) *G. cuneifolia*.—Stems pinkish to purplish-brown. Leaves oblong to cuneate-oblong, up to 9.8 cm. long, margin serrated above and entire below.
- (c) *G. squarrosa*.—Stems greyish-green to yellowish. Leaves oblong, up to 5 cm. long, margin dentate.

Constituents and Uses.—Grindelia contains about 21 per cent. of amorphous resins, fat, colouring matter and a trace of volatile oil. It is used in spasmodic asthma, hay fever, whooping cough, and bronchitis. A lotion prepared from it is used in the treatment of dermatitis produced by *Rhus toxicodendron* (poison ivy).

PYRETHRI FLORES

Flores Insectorum; *Insect Flowers*, *Pyrethrum Flowers*, *Dalmatian Insect Flowers*; *F. Fleurs de Pyrèthre (ou Chrysanthème) Insecticide*; *G. Insektenblüten*

Source.—Insect flowers are the dried flower-heads of *Chrysanthemum cinerariæfolium* Visiana (*Pyrethrum cinerariæfolium* Trev.), a plant about 1 metre high indigenous to the Balkans. The plant is now very widely cultivated, being grown in Dalmatia, Herzegovina, Montenegro, the Dalmatian and Istrian Islands, Italy, Spain, France, Germany, England, Australia, Kenya, California, and Japan.

History.—The insecticidal properties of Persian or Caucasian insect flowers (*C. roseum* Weber and Moor and *C. Marshallii* Aschers) have long been known in their country of origin, but the use of the Dalmatian species dates from the middle of the last century. Persian insect flowers are now rarely seen in British commerce.

Collection.—It was formerly believed that the closed flowers were more active than the open ones, but experiments have

since shown that there is little difference in activity between them. In Dalmatia, however, as the flowers are cut by hand they are divided into three grades, consisting of "closed," "half-closed," and "open" flowers. The stalks are not devoid of insecticidal properties and are often collected separately. The method of drying varies in different localities, but in warm climates drying in the sun for two or three days is usual. The flowers rapidly decrease in activity if carelessly stored.

Characters.—The closed flower-heads are about 6 to 9 mm. in diameter and the open ones about 9 to 12 mm. in diameter. They bear a short peduncle, which is striated longitudinally. The involucre consists of two or three rows of yellowish or greenish-yellow, lanceolate, hairy bracts. The receptacle is nearly flat and devoid of palæ. It bears numerous, yellow tubular florets and a single row of cream- or straw-coloured ligulate florets. The ligulate corollas are 10 to 20 mm. in length and have about seventeen veins and three rounded teeth, the centre one very small (distinction from ox-eye daisies, *C. Leucanthemum*, in which the ligulate corollas have seven veins and three teeth, the centre one being the largest). The achenes are five-ribbed (achenes of Persian flowers usually ten-ribbed). The flowers have a slightly aromatic odour and a bitter, acrid taste.

Characters of Powders.—The species specified for use by the U.S. Insecticide Board are *C. cinerariaefolium*, *C. roseum*, and *C. Marshallii*, the powders from which show the following elements: parenchyma often containing aggregate crystals, T-shaped hairs, numerous spherical pollen grains, sclerenchymatous cells (particularly from Persian flowers), tracheids, and epidermal cells having a striated, papillose cuticle.

Adulteration.—Insect powder frequently contains an excessive amount of stem and leaf. The amount of stem may be judged by the amount of collenchymatous tissue seen in powder, whilst leaf is shown by the greenish colour given to an ethereal extract. Many other adulterants, for example foreign composite flowers and inorganic matter, have been recorded. The quality may be judged by microscopical examination (including counts of typical pollen grains), by tests on flies, and by the amount of ash and ethereal extract. Samples normally yield 6 to 7 per cent. of ash and about 7.5 to 10.5 of ethereal extract.

Constituents.—The flowers owe their insecticidal properties

to two esters, pyrethrin I and pyrethrin II, which were isolated by Staudinger and Ruzicka in 1924. These are present to the extent of about 0.2 to 0.3 per cent. The flowers also contain volatile oil, resin, a glycoside, and an alkaloid.

Pyrethrin I is an ester of a ketonic alcohol, pyrethrolone, and an acid, chrysanthemumcarboxylic acid, $C_{10}H_{16}O_2$. Pyrethrin II is an ester of pyrethrolone and chrysanthemumdicarboxylic acid, $C_{10}H_{14}O_4$. Pyrethrin I is more active than pyrethrin II; the acids and ketonic alcohol derived from them are devoid of insecticidal properties.

Uses.—Insect flowers are largely used in the form of powder, but sprays made from them are more efficient. Some of the earlier sprays rapidly decreased in activity, but suitable solvents have now been found.

CALENDULÆ FLORES

Calendula; *Calendula* or *Marigold Florets*; F. *Fleurs de Tous les Mois*; G. *Ringelblumen*, *Goldblumen*

Source.—*Calendula* consists of the dried, ligulate corollas of the marigold, *Calendula officinalis*, a plant widely cultivated in England and Europe.

Characters.—Each ligulate corolla is about 15 to 25 mm. in length and orange-yellow in colour. When soaked in water the three teeth (occasionally fewer) and four principal veins are easily seen. The corolla is contracted at the base into a short, hairy tube in which the remains of the style and bifid stigma are sometimes seen. Odour, aromatic; taste, bitter.

Constituents.—*Calendula* contains traces of volatile oil, a bitter principle and gummy matter ("calendulin," Geiger, 1818).

Uses.—*Calendula* is now almost obsolete as a drug. It has been used to adulterate saffron and arnica flowers and has been sold as Chinese safflower or feminell.

ARNICÆ FLORES

Arnica; *Arnica Flowers*; F. *Fleurs d'Arnique*; G. *Arnikablüthen*

Source.—*Arnica* consists of the dried flower-heads or flowers of *Arnica montana*, a small, perennial herb found in alpine meadows in Central Europe. The drug sometimes consists of

the whole flower-heads, sometimes of the florets only. Several Continental pharmacopœias specify the florets only since the receptacles often contain the larvæ of *Trypeta arnicivora*.

Characters.—The receptacle, if present, is about 8 mm. in diameter and is slightly convex. It bears pits, corresponding to the position of the flowers, in each of which is a stiff bristle. The involucre consists of two rows of dark green, hairy, lanceolate bracts about 1 cm. in length.

The pistillate, ligulate florets are about 3 cm. long. Each consists of a yellow corolla having three teeth and seven to twelve veins, a style and stigma, and a pubescent, dark brown achene 5 to 7 mm. long. The latter is pubescent and glandular and is surmounted by a large, white pappus consisting of very characteristic, barbed bristles. The disc florets resemble the ligulate ones but have a tubular corolla and are hermaphrodite. When examined microscopically, numerous spiny pollen grains and the form of the hairs are seen. Odour, slight but agreeable; taste, bitter and acrid.

Constituents.—Arnica contains about 0.5 per cent. of volatile oil, a bitter principle (arnicin), resin, colouring matter, and arnidiol (arnisterin).

Uses.—A diluted tincture of arnica is used for bruises and sprains.

Allied Drug.—*Arnica rhizome* consists of the dried rhizome and roots of *Arnica montana*. The rhizome is dark brown in colour, about 2 to 10 cm. long, and 2 to 6 mm. in diameter. It bears numerous wiry roots and cataphyllary leaves. The transverse section shows a yellowish bark containing oleo-resin ducts, a ring of wedge-shaped vascular bundles, and a large pith. The constituents are similar to those of the flowers. About 10 per cent. of inulin is also present, but starch is absent.

SANTONICA

Flores Cinæ, Semen Cinæ, Semen Contra; Santonica Flowers, Wormseed; F. Semencine, Barbotine; G. Zitwersamen, Wurmsamen

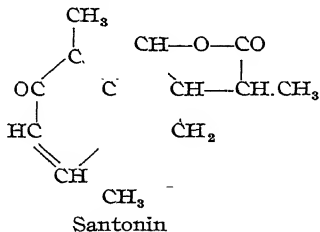
Source.—The wormseed usually found in British commerce consists of the dried, unexpanded flower-heads of *Artemisia cina* Berg, a plant about 0.5 metre high which is very abundant in Turkestan. The drug is used for the extraction of santonin,

large quantities of which are produced at Chimkent. Santonin is also present in other species of *Artemisia*, some of which may become commercially important.

History.—The drug, or one closely resembling it, was known to Dioscorides and was used as a vermifuge. He also mentions a similar plant growing in Gaul in the country of the Santones. The drug has been in continued use since that period, but is now usually replaced by its active principle santonin, which was discovered in 1830 by Kahler.

Characters.—The drug consists of oval, yellowish or brownish flower-heads about 1.5 to 4 mm. in length. A few of these should be boiled with solution of chloral hydrate and examined under the low power of a microscope. The flower-head consists of an involucre of about sixteen bracts, which completely enclose from two to five more or less immature tubular florets. If pressure be applied to the coverslip, under which the flower-head has been mounted, the florets separate from the axis and bracts. Their corollas and pollen sacs may be easily seen.* Wormseed has an aromatic odour and a bitter, camphoraceous taste.

Constituents.—The chief anthelmintic constituent of the drug is santonin, the crystalline lactone of santoninic acid. It has the following structure.†



Santonin is extracted as follows: The flower-heads are treated with milk of lime and calcium santoninate is formed. This is converted into soluble sodium santoninate by inter-action with sodium hydroxide or sodium carbonate, and the calcium, which is precipitated by means of carbon dioxide, is filtered off. Sulphuric acid is added to the filtrate when impure santonin is precipitated. This is redissolved, de-colourised, and purified by recrystallisation.

* For further details, see Wallis's *Practical Pharmacognosy*, p. 37.

† Clemo, Haworth, and Walton, *J.C.S.*, 1930, 1110.

Wormseed also contains a little volatile oil and a second, crystalline lactone, artemisin, closely related to santonin.

Artemisia cina yields about 2.3 to 3.6 per cent. of santonin, the maximum amount, according to Ehlinger (1885), being present in July and August. Santonin has also been obtained from European species of *Artemisia*, Dutch plants yielding about 1.3 per cent. and Scotch ones about 0.68 per cent. of santonin. Santonin is present in certain Indian species of *Artemisia*.

Uses.—Wormseed has been replaced by santonin, which is very efficient in its action on round worms. It has less effect on thread worms, and none whatever on tænia.

INULÆ RHIZOMA

Inulæ Radix; *Elecampane* or *Inula Root*; †. *Racine d'Aunée*; G. *Alantwurz*

Source.—*Inula* consists of the dried rhizomes and roots of *Inula Helenium*, a perennial herb about 2 metres in height which is commonly grown in England and on the Continent.

Characters.—The drug consists of more or less obliquely-sliced rhizomes up to 8 cm. in length and 5 cm. in diameter, together with pieces of gradually tapering roots up to 13 cm. in length and 3 cm. in diameter. The outer surface is greyish-brown and longitudinally wrinkled. The drug is very hard and breaks with a short, horny fracture.

The bark and wood contain oil glands which may be seen with the naked eye. By means of a microscope abundant fan-shaped masses of inulin may also be seen. Odour, aromatic; taste, aromatic and bitter.

Constituents.—When steam distilled, *inula* yields about 1 to 2 per cent. of volatile oil which separates into a crystalline inodorous mass (alantolactone, *isoalantolactone*, and alantolic acid) and an oily liquid (alantol) having an odour of peppermint (Kallen, 1873 and 1876). When collected in the autumn the rhizome contains about 45 per cent. of inulin.

Uses.—*Elecampane* and *alantol* were at one time recommended for tuberculosis and bronchitis, but the drug is now almost obsolete.

TARAXACI RADIX

Taraxacum or Dandelion Root ; F. Pissenlit ; G. Löwenzahn

Source.—*Taraxacum* root of the 1914 Pharmacopœia was the fresh root of *Taraxacum officinale*, collected in the autumn.

Characters.—The vertical rhizome and taproot pass almost imperceptibly into one another. They measure about 30 cm. in length and from 5 to 25 mm. in diameter. The outer surface is yellowish-brown. The fresh root is fleshy and when cut exudes abundant white latex.

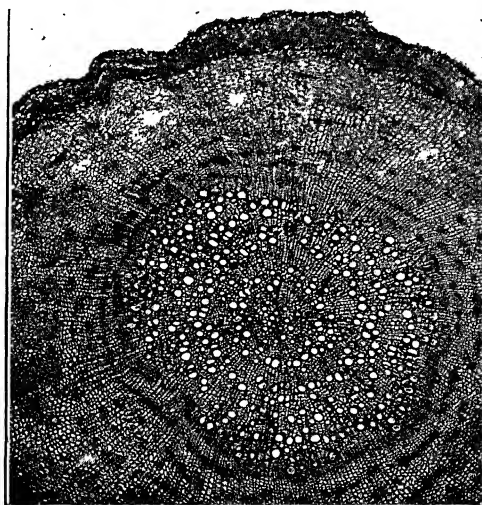


FIG. 219.—*Taraxacum officinale*. Transverse section of root showing concentric rings of latex vessels (Sutcliffe).

Sections passing through the upper portion show a stem-like structure, namely, a relatively thin bark, a ring of wood bundles, and a distinct pith. A transverse section of the taproot (Fig. 219), on the other hand, shows a wider bark, a small, yellowish, central wood, and no pith. In the bark of both rhizome and root are concentric zones of anastomosing latex

vessels, and abundant inulin-containing parenchyma. Odour, slight; taste, bitter.

Constituents.—"Taraxacin" and "taraxacerin" isolated in 1839 and 1861 respectively, are said by Power (1912) to be indefinite mixtures. Power found in the dry root an enzyme, volatile oil, resin, and fatty acids. The autumn root contains about 25 per cent. of inulin, whilst the spring root is rich in sugars.

Uses.—*Taraxacum* has been widely used for its supposed laxative and diuretic properties, but is now seldom prescribed. As it resembles chicory in structure, it has often been used for adulterating chicory or mixtures of coffee and chicory.

PART IV
DRUGS OF ANIMAL ORIGIN

CHAPTER XXII

INTRODUCTION

As in the case of the Vegetable Kingdom, animals are classified into Phyla, Classes, Orders, Families, Genera, and Species. For details of zoological classification and animals such as the malarial parasite and the tapeworm, which are of medical rather than pharmaceutical interest, textbooks of zoology should be consulted. The following is a summary of the animals and animal products mentioned in this book :—

Phylum.	Class.	Order.	Animal or Animal Product.
Protozoa	Rhizopoda	Foraminifera	Chalk (see p. 150).
Porifera	Calcarea Non-calcarea		Calcareous sponges. Non-calcareous sponges, which often possess siliceous spicules (see Kieselguhr, p. 148, and agar, p. 182).
Annelida	Hirudinea	Gnathobdel- lida	Leech.
Arthropoda	Insecta Arachnida	Coleoptera Hymenoptera Hemiptera Lepidoptera Acarida	Beetle pests (see p. 69), Cantharides and Mylabris. Honey and beeswax. Cochineal and shellac. Moth pests (see p. 70) and silk (p. 127). Mite pests (see p. 71).
Mollusca	Cephalopoda	Decapoda	Cuttlefish shell.
Chordata (Vertebrata)	Pisces Mammalia	Teleostei Cetacea Ungulata	Cod-liver oil and halibut- liver oil. Spermaceti and Ambergris. Lard, suet, wool (p. 125), wool fat, gelatin, and musk.

CHAPTER XXIII

ANIMALS AND ANIMAL PRODUCTS

HIRUDO

Leech ; *F. Sangsue* ; *G. Blutegel*

Source.—The leech usually employed in Britain is the speckled, green, or grey leech, *Hirudo medicinalis* (Phylum Annelida, Class Hirudinea, Order Gnathobdellida, Family Hirudineæ). They are usually bred in ponds on the Continent. In addition to the above species, *Hirudo quinquestriata*, the five-striped or Australian leech, was formerly official. In America the native *Hirudo decora* is sometimes used.

Collection and Preservation.—Leeches may be collected in nets or by paddling. They are usually kept in jars tightly covered with a linen cloth. The water should be changed about three times a week and kept at a uniformly moderate temperature. A few pieces of moss or roots and some pebbles and sand should be added so that the animals may clean themselves from the slime which tends to form on their coats. They need very little food, but the addition of a few pieces of Irish moss to the water in which they are kept has been recommended. After use leeches disgorge the blood they have swallowed when placed in salt water, but the use of the same leech for different patients has been condemned as it may be a means of carrying infection.

External Characters.—Leeches are about 6 to 10 cm. in length and dorsiventrally flattened. The anterior end possesses a cup-like hollow or sucker. In the centre of this is the mouth with three radiating jaws provided with chitinous serrations or "teeth," which acting together produce a characteristic triradiate bite. This disc also bears ten small black groups of sensory papillæ or "eyes." The body shows about 100 annulations. The dorsal surface of *H. medicinalis* bears six

alternating longitudinal bands of greenish-grey and rusty red ; the ventral surface is greenish-yellow with black spots. *H. quinquestriata* has five, greenish-brown stripes on the dorsal surface and a greenish-yellow ventral surface without spots. At the posterior end of the leech is a second sucker. The animal is a good swimmer and moves on solid objects with a "looping" movement, attaching itself by the sucking-discs and alternately contracting and elongating its body.

Uses.—Leeches, although much less used than formerly, are often the least painful means of reducing inflammation. They should be applied to the moistened skin, and if required to bite a particular spot a suitable sized hole may be cut in a piece of blotting paper or in a pill-box. A leech draws 4 to 8 ml. of blood, and the amount may be increased by afterwards fomenting. The animals may be removed from the skin by sprinkling them with salt.

The salivary glands of the leech produce a substance, *herudin*,* which retards the coagulation of blood. Extracts of leech heads have been used in the physiological laboratory and, to a limited extent, in medicine.

CANTHARIS

Cantharides, Spanish or Russian Flies, Blistering Beetles ;
F. *Cantharide* ; G. *Kantharide*

Source.—*Cantharides* consists of the dried insects *Cantharis vesicatoria* Latreille (Order Coleoptera, Family Meloïdæ). *Cantharides* are collected in South Russia, the Balkans, Sicily, and Spain.

Collection and Preparation.—The mature insects usually make their appearance in May and June, when they collect on such plants as the white poplar, privet, ash, and elder. In the very early morning, when the insects are still sluggish from the night air, the trees are shaken or beaten with poles and the insects which fall off are collected on cloths. The collectors protect their hands and faces.

The insects are killed by plunging them into dilute vinegar or exposing them in sieves to the vapour from hot vinegar (the method described by Dioscorides and Pliny), or the fumes of ammonia, burning sulphur, carbon disulphide, or chloro-

* According to the U.S. *Dispensatory*, *hirudin* is a commercial name for a preparation manufactured from leech heads.

form. When dead, they are dried in the sun or by artificial heat and packed in casks or boxes lined with paper.

Characters.—Cantharides are 15 to 25 mm. in length and from 5 to 8 mm. in breadth. As with other beetles the insect possesses a pair of wing-cases or elytra, which protect a pair of transparent, membranous wings. The elytra are coppery green in colour and the wings brown. The chief regions of the insect are the head, to which is attached a pair of long antennæ, the thorax, which bears three pairs of legs, and the abdomen, which is almost completely covered by the elytra when these

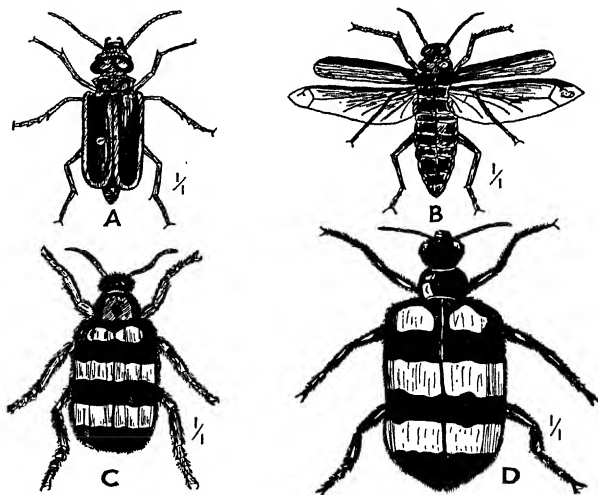


FIG. 220.—A and B, *Cantharis vesicatoria*; C, *Mylabris cichorii*; D, *Mylabris sidea*. (A to C after Martiny, D after Wallis.)

are closed. Dried cantharides have an unpleasant odour which is even more marked in the fresh insects. For details of the dissection of cantharides see Wallis's *Practical Pharmacognosy*. Before dissection, cantharidin should be removed by soaking the beetles in acetone.

Cantharides is a drug which is particularly liable to attack by moths (species of *Tinea*) and mites. The author has recently examined some fifty samples, mostly from students' materia medica sets, and every one was damaged to some extent.

Constituents.—Cantharides contain 0.5 to 0.9 per cent. of a colourless, crystalline compound, cantharidin, $C_{10}H_{12}O_4$. Cantharidin is the inner anhydride of a dibasic acid, cantharidic acid. The insects contain both cantharidin and salts of cantharidic acid. Cantharidin on treatment with alkalis forms soluble cantharidates, but solutions of the latter when acidified yield a precipitate of cantharidin. The insects also contain about 12 per cent. of fat which is associated with the cantharidin and cantharidates in the softer parts of the body.

Cantharidin is official. Its preparation involves the liberation of cantharidin present in the form of salts by means of acid, and extraction of both cantharidin and fat by means of a solvent such as ethyl acetate. The solvent is recovered and impure cantharidin crystallises out. The fat may then be removed with light petroleum (in which cantharidin is only slightly soluble), and the crude cantharidin recrystallised from hot alcohol.

Allied Drugs.—A considerable number of beetles which possess vesicant properties are described and illustrated by Tschirch. Of these Chinese cantharides or *Mylabris* beetles are regularly imported. They are found in China, the Malay Peninsula, and India. They contain from 1.0 to 1.2 per cent. of cantharidin.

Mylabris sidæ Fabr. (*M. phalerata* Pallas) is about the same size as *Cantharis vesicatoria*, the length varying from 12 to 30 mm. The elytra are black and orange-yellow, each showing a large, yellow spot near the anterior end and two broad yellow bands. The insects are hairy and on the yellow parts of the elytra the hairs are black and bristly.

Mylabris cichorii Fabr. closely resembles *M. sidæ* but is usually smaller, measuring about 10 to 15 mm. in length. The yellow parts of the elytra are somewhat brighter than those of *M. sidæ* and possess yellow downy hairs.

Uses.—Cantharidin is a very powerful irritant and is seldom employed internally. It is used in the form of plasters, blisters, collodions, etc., as a rubefacient and vesicant, and is sometimes included in preparations intended to stimulate the growth of hair.

MEL

Honey ; F. Miel ; G. Honig

Source.—Honey is a saccharine substance deposited by the hive bee, *Apis mellifica* Linn. (Order Hymenoptera, Family Apidæ), and other species of *Apis*, in the cells of the honey-comb. Honey is produced in England, but the chief sources of supply are the West Indies, California, Chile, various parts of Africa, Australia, and New Zealand.

Collection and Preparation.—A bee may be dissected as described in Wallis's *Practical Pharmacognosy*. The worker bees, by means of a long, hollow tube formed from the maxillæ and labium, take nectar from the flowers they visit and pass it through the œsophagus into the honey-sac or crop. The nectar, which consists largely of sucrose, is mixed with salivary secretion containing the enzyme invertase, and while in the honey-sac is hydrolysed to invert sugar (p. 27). On arrival at the hive the bee brings back the contents of the honey-sac and deposits them in a previously prepared cell of the honey-comb.

The best honey is that derived from flowers such as the clover and heather, obtained from hives which have never swarmed, and separated from the cut comb either by draining or by means of a centrifuge. Centrifuges are now usually used on a large scale. The nectar of certain flowers, *e.g.* of species of *Eucalyptus*, may give the honey a somewhat unpleasant odour and taste. Honey is sometimes obtained by expression, but is then liable to be contaminated with the wax.

Characters.—Honey, when freshly prepared, is a clear, syrupy liquid of a pale yellow or reddish-brown colour. On keeping it tends to crystallise and become opaque and granular. The odour and taste depend very largely on the flowers used in its preparation.

Constituents.—Honey consists mainly of invert sugar and water. It contains small quantities of sucrose, dextrin, formic acid, volatile oil, wax, and pollen grains. Microscopical examination of the latter affords valuable evidence of the source. The most likely adulterants are artificial invert sugar, sucrose, and commercial liquid glucose. The tests for purity of the official purified honey should be noted. The limit tests for chloride and sulphate are important, as starch and sucrose may be hydrolysed with acids to give commercial liquid

glucose and artificial invert sugar respectively. Artificial invert sugar contains furfural, which gives a red colour with resorcinol in hydrochloric acid.

Uses.—Honey is chiefly used in pharmacy in the form of Honey of Borax and the oxymels.

CERA FLAVA ET ALBA

Yellow Beeswax, White Beeswax ; F. Cire Jaune, Cire Blanche ; G. Gelbes Wachs, Weisses Wachs

Source.—Beeswax is obtained by melting and purifying the honeycomb of *Apis mellifica* and other bees. The wax is imported from the West Indies, California, Chili, Africa, Madagascar, and India.

Preparation.—Wax is secreted by worker bees in cells on the ventral surface of the last four segments of their abdomen. The wax passes out through pores in the chitinous plates of the sternum and is used, particularly by the young workers, to form the comb.

Yellow beeswax is prepared, after removal of the honey, by melting the comb under water (residual honey dissolving in the water and solid impurities sinking), straining, and allowing the wax to solidify in suitable moulds.

White beeswax is prepared from the above by treatment with charcoal, potassium permanganate, chromic acid, chlorine, etc., or by the slow bleaching action of light, air, and moisture. In the latter method the melted wax is allowed to fall on a revolving cylinder which is kept moist. Ribbon-like strips of wax are thus formed which are exposed on cloths to the action of light and air, being moistened and turned at intervals until the outer surface is bleached. The whole process is repeated at least once, and the wax finally cast into circular cakes.

Characters.—Beeswax is a yellowish-brown or yellowish-white solid. It breaks with a granular fracture and has a characteristic odour.

It is insoluble in water and sparingly soluble in cold alcohol, but dissolves in chloroform and in warm fixed and volatile oils (*e.g.* oil of turpentine).

Constituents.—Beeswax is a true wax consisting of about 80 per cent. of melissyl palmitate (myricin), $C_{15}H_{31}.COOC_{30}H_{61}$, with possibly a little melissyl stearate. It also contains about

15 per cent. of free cerotic acid, $C_{26}H_{53}.COOH$, and an aromatic substance cerolein.

Adulterants.—The most likely adulterants and their methods of detection will be found in the Pharmacopœia. Japan wax, which is there mentioned, is not a true wax but a fat and may be saponified by means of boiling aqueous sodium hydroxide. Waxes are saponified by strong alcoholic potash, but are practically unaffected by aqueous alkali. Japan wax is prepared from the fruits of various species of *Rhus* (Fam. Anacardiaceæ).

Uses.—Beeswax is used in the preparation of plasters, ointments, and polishes.

COCCUS

Coccus, B.P., *Coccus Cacti* ; *Cochineal* ; F. *Cochenille* ;
G. *Scharlachwurm*

Source.—Cochineal is the dried female insect *Dactylopius coccus* Costa (Order Hemiptera), containing eggs and larvæ. Cochineal insects are indigenous to Central America. Commercial supplies are derived from the Canary Islands, Algiers, and Honduras.

Culture and Life History.—Each year eggs from the previous crop, which are protected during the rainy season by shelters placed over the plants, are "sown" on the cacti (usually species of *Nopalea*) on which it is intended to breed. Both male and female insects emerge. The males are about 1 mm. long and possess wings, while the females are about 2 mm. long and without wings. After a time fecundation takes place and the females attach themselves to the cacti by means of their probosces, which are firmly embedded in the tissues of the plant. The males then die. The females swell to about twice their former size, owing to the presence of developing larvæ, and develop red colouring matter. The larvæ mature in about fourteen days and escape from the now dead body of the parent. Only a small proportion of the larvæ develop into males. For the next fortnight the young females crawl about the plant and the males fly. The sequence of events described above is then repeated. The life cycle thus takes about six weeks and three to five generations of the insects may be produced in a season.

Collection and Preparation.—The insects are brushed from the plants with small brooms and killed, a certain number

being left to provide for subsequent crops. The first crop of the season usually contains the most colouring matter. The insects are killed by plunging in boiling water, by stove heat, or by exposure to the fumes of burning sulphur or charcoal. If heat is used the insects change to a purplish-black colour and are known as "black grain," whilst the fume-killed purplish-grey ones are known as "silver grain." Small immature insects and larvæ which can be separated by sieves are sold as "granilla" or siftings.

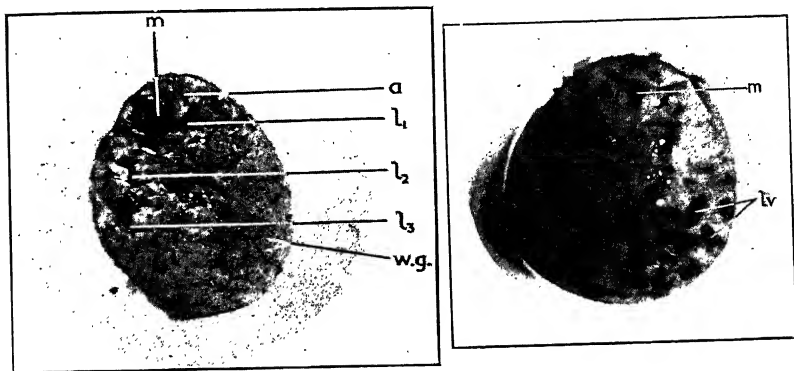


FIG. 221.—Cochineal insects $\times 10$. m, mouth; a, antenna; l_1 , l_2 , l_3 , legs of the first, second and third pairs; w.g., wax glands; lv., larvæ. (Sutcliffe.)

Characters.—Cochineal insects are 3.5 to 5.5 mm. in length and somewhat oval in outline. The convex dorsal surface shows about eleven segments, but there are no constrictions between head, thorax, and abdomen. The insect has a pair of seven-jointed antennæ and three pairs of very inconspicuous legs (Fig. 221, 1). The surface bears tubular glands which secrete wax, the melting of which by heat accounts for the difference in colour between the silver grain and black grain varieties.

Cochineal should be examined microscopically as described in Wallis's *Practical Pharmacognosy*, after removing the colouring matter by means of solution of ammonia. Within each insect will be found from 60 to 450 eggs and larvæ (Fig. 221, lv).

Constituents.—Cochineal contains about 10 per cent. of carminic acid, a brilliant purple, water-soluble colouring matter, the exact chemical nature of which is doubtful. The insects also contain about 10 per cent. of fat and 2 per cent. of wax. Carmine is a preparation of cochineal containing about 50 per cent. of carminic acid.

Adulteration.—The weight of cochineal may be increased by “dressing” it with inorganic matter, the colour of which is chosen so as to blend with the variety of insect being adulterated. If genuine, no insoluble powder should separate when the insects are placed in water and the ash should not exceed 7 per cent.

Uses.—Cochineal is employed as a colouring agent and as an indicator in certain titrations.

LACCA

Lac, Shellac ; F. Laque, Gomme Lacque ; G. Lack, Gummilack

Source.—Lac is a resinous substance prepared from a secretion that encrusts the bodies of a scale insect, *Laccifer lacca* Kerr (*Tachardia lacca* R. Blanchard) (Order Hemiptera, Family Coccidæ). Lac is produced in Burma, Assam, and India (particularly in Bihar and Orissa, the Central Provinces, and Sind). The annual production of stick lac in India is over 36,000 tons. The insects live on the juices of various trees which are grown for their use. The chief plants are members of the Leguminosæ (*Acacia* spp., *Butea frondosa*), Euphorbiaceæ (*Aleurites laccifera*), Moraceæ (*Ficus* spp.), Dipterocarpaceæ (*Cajanus indicus*, *Shorea talura*), Rhamnaceæ (*Zizyphus jujuba*), and Sapindaceæ (*Schleichera trijuga*).

The insects resemble cochineal in structure and life-history. The females are about 0.5 mm. in length and after attaching themselves to the bark of a tree by their probosces they lose their legs. Most of the host plants contain tannins, gums, and hydroxy-acids, and it is thought that the insect lives on bacteria-produced gums which it sucks from the plant tissues. As in the case of cochineal the insect possesses secretory glands which, after fecundation has taken place, secrete wax and resin in such quantities as to completely cover the insects and twigs. The bodies of the insects contain a colouring matter resembling carminic acid.

Collection and Preparation.*—Lac is found most abundantly on the smaller branches and twigs. These are broken off and constitute *stick lac*. Usually, however, the lac is not exported in this form but is scraped from the twigs by means of curved knives. Stick lac of English commerce therefore consists of channelled pieces of resin containing the dead bodies of the insects and up to 7 mm. in thickness, or the same in small deep red fragments. Occasional twigs of small size may be enclosed in some of the pieces. The lac is usually ground in India and the colouring matter extracted with water or dilute soda solution. The solution evaporated to dryness constitutes *lac dye*, and the exhausted lac when dried *seed lac*. The latter is melted in a long sausage-shaped bag suspended over a charcoal fire and the lac squeezed out. When sufficiently cool the product is seized with hands, feet, and mouth, and stretched into a large sheet. The latter is broken up and constitutes the flake shellac of commerce.† Sometimes the lac is poured into circular moulds and, when sufficiently cool, stamped with the maker's name. This variety is known as *button lac*. *Bleached shellac* is a form prepared by dissolving lac in hot soda solution, bleaching with chlorine or sulphurous acid, precipitating with acid, collecting, washing, and "pulling" under water into sticks. If kept under water it is soluble in alcohol and wood naphtha, but the solubility decreases on exposure.

Characters.—Flake shellac occurs in thin, very brittle, translucent fragments. Various grades and colours are employed for particular purposes. That having a brownish-yellow colour is known as orange shellac, and the darker, reddish-brown varieties are known as ruby or garnet shellac.

Shellac is insoluble in water, but soluble in alcohol and in alkaline solutions. Petroleum extracts only the waxy portion, which constitutes about 5 to 6 per cent. The iodine value of pure shellac varies from 4 to 10, higher values usually indicating addition of colophony.

Constituents.—Lac contains about 6 per cent. of wax, 6.5 per cent. of the red colouring matter, laccaic acid, 70 to

* A map of the producing districts and six photographs illustrating *The Lac Industry in India* may be obtained from the Imperial Institute. Similar illustrations will be found in Tschirch's *Handbuch der Pharmakognosie*.

† At one time resin and orpiment were often added to shellac, but such additions are now usually regarded as adulteration. See "Shellac in the B.P.C.: A Criticism," by E. J. Parry, *C. and D.* 1935, 46.

85 per cent. of resin, and smaller quantities of insect remains, vegetable debris, etc.

About 65 per cent. of the resin is insoluble in ether, while the remainder dissolves in ether containing a little alcohol. The ether-insoluble resin yields free aleuritic acid [trihydroxypalmitic acid, $C_{15}H_{28}(OH)_3.COOH$], and a mixture of resin acids, one of which is shelloic acid, $C_{15}H_{20}O_6$. The resin appears to consist largely of the lactides of hydroxy acids.

Uses.—Shellac is used in varnishes, polishes, sealing wax, etc.

OS SEPIÆ

Cuttlefish Bone or Shell ; F. *Os de Sèche* ; G. *Sepie*, *Weisses Fischbein*

Source.—Cuttlefish bone is the internal shell of the cuttle, *Sepia officinalis* (Phylum Mollusca, Class Cephalopoda, Order Decapoda). The cuttlefish belongs to the same order as the



FIG. 222.—Emptying a case of cuttlefish bone (*Chemist and Druggist*).

squids and has ten arms with stalked suckers surrounding the mouth, while the closely related octopi have eight arms. These animals possess an ink gland which in the case of the cuttlefish is separated and used in making the water-colour *sepia*. The animal possesses an internal, calcareous skeleton. After death these shells are often thrown up by the sea and may be collected. They are quite common on the shores of Europe and the Indian Ocean.

Characters.—Cuttlefish shells are oblong-oval, biconvex, about 20 cm. long, 7 cm. wide, and 2 cm.

thick. The outer surface is chitinous, but the inner part is friable and porous.

Constituents.—Cuttlefish shells contain 80 to 85 per cent. of calcium carbonate, 10 to 15 per cent. of organic matter, and small quantities of calcium phosphate and sodium chloride.

Uses.—The shells are used in considerable quantities in dentifrices, and have been employed internally as an antacid.

OLEUM MORRHUÆ

Oleum Morrhuæ, B.P.; *Oleum Jecoris Aselli*; *Cod-Liver Oil*; F. *Huile de Morue*; G. *Lebertran*, *Stockfischlebertran*

Source.—Medicinal cod-liver oil is a fixed oil prepared from the fresh liver of the cod, *Gadus morrhua* (Order Teleostei, Family Gadidæ), under conditions which give a palatable oil containing a due proportion of vitamins. Large quantities are prepared on the north-west coast of Norway (Lofoten Islands and Finmarken being the principal fishing areas), and smaller quantities in Newfoundland, Scotland, and Iceland.

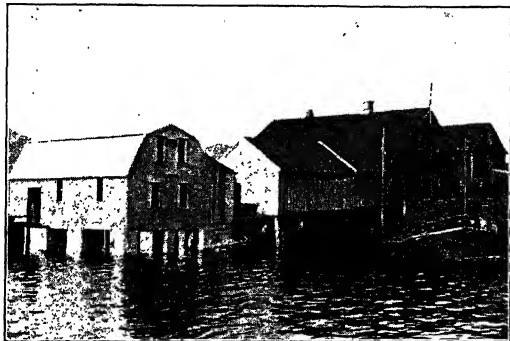


FIG. 223.—A typical Norwegian cod-liver oil factory: Southall Bros. & Barclay, Ltd., Balsatad, Lofoten Islands.

History.—Cod-liver oil was exported from Norway during the Middle Ages, but it appears to have been used solely for technical purposes. Its introduction into medicine was largely due to Dr. Samuel Kay, a physician at Manchester Infirmary from 1752 to 1784. The original method of preparation was the "rotting process," in which the livers were allowed to rot in barrels and the oil rising to the surface was skimmed off. The more modern "steaming process" was introduced about 1850.

Collection and Commerce.—Off the Lofoten Islands enormous shoals of cod are found from the end of January to April, while at Finmarken they do not as a rule appear until May. The Finmarken fishing usually closes at the end of June or early in July. Conditions are very favourable in Norway for the production of good oil since the normal temperature during the fishing season is -7° to $+3^{\circ}$ C., while the factories, one of which is shown in Fig. 223, are so placed that the fishing fleet is never out of sight. The fish are caught by nets or lines and usually landed about mid-day. On arrival the fish are opened and separated into livers, roes, heads, and edible flesh. The roes are frozen and exported, the heads



FIG. 224.—Part of a battery of "cookers" used in the manufacture of Southall's "A1" cod-liver oil. The upper portion only is shown, the lower portion being on the floor below.

dried and ground as fish guano, and the remainder of the carcase dried on poles in the open air (stockfish) or salted and dried on the rocks (klipfish). The livers are freed from the gall bladders and washed ready for the extraction process.

In Newfoundland the season is June to September, when the livers are rather less rich in oil but have a high vitamin content. The fish are caught inshore and the extraction of the oil is commenced within an hour or two. In 1921 Newfoundland produced about 46,000 gallons of oil, in 1926 169,000 gallons, and in 1931 118,000 gallons.

Extraction.—The livers used must be perfectly healthy ones, freed from gall bladders, and must be treated within a few

hours of the fish being caught. "The activity of the autolytic enzymes of fish livers is truly remarkable. Even at temperatures approaching freezing point appreciable hydrolysis of fat will occur in a few hours." *

The livers are placed in steam-jacketed, tapering "kars" commonly holding 6 to 8 hectolitres (12 to 16 cwt.) of livers, which are completely closed during the cooking or steaming (see Fig. 224). Formerly live steam was rarely admitted to the contents, but modern practice favours the use of a higher temperature, which more rapidly destroys the autolytic enzymes, while the admission of steam facilitates mixing and disintegration of the livers. The steam may be admitted by means of a vertical pipe which is perforated near the base. Drummond and Hilditch, using an apparatus of this type with a 5 cwt. charge of livers and steam at 50 to 60 lb. pressure, found that twelve to fifteen minutes was required to reach the boiling-point and the operation was usually completed in twenty to twenty-five minutes.† These workers recommend the use of steam at 80 to 100 lb. pressure if circumstances permit. After steaming and allowing to settle for about five minutes the oil is run off into cooling tanks, which are made with floating covers to protect the oil from the air. In Newfoundland the oil, after cooling for thirty-six hours, is filtered through double calico bags into tin-lined barrels. In Norway the oil is frequently filled into metal containers holding 25 to 30 gallons, which are buried in the snow for several days, the oil being then filtered through a press into the tin-lined barrels in which it is exported. As much as 20 to 25 per cent. of "stearine" may be deposited during the cooling. Non-destearinated cod-liver oil is official in the U.S.P. XI. under the name *Oleum Morrhuæ Non-destearinatum*. After extracting the No. 1 oil, water may be added to the extractor and the contents brought to the boil with steam. The water is then drained off and the hot blubber placed in press bags and immediately pressed to give a further yield of oil.

Refining.—"It is recommended that wherever possible the only refining process employed should consist of intensive

* Drummond and Hilditch, "The Relative Values of Cod-Liver Oils from Various Sources," Publication No. 35 of the Empire Marketing Board,

3-.

† In the rules issued for the guidance of Newfoundland manufacturers the worker is directed to "boil until the white scum floats (which will take about 30 minutes)."

chilling followed by filtration or centrifuging at a low temperature; whilst, if any further decolorising or deodorising action is necessary, it should be restricted to agitation at as low a temperature as possible with fuller's earth or similar adsorbent material, fuller's earth and charcoal being indicated as a particularly suitable mixture." *

Storage.—Providing the containers are filled as completely as possible, the amount of air enclosed is insufficient to bring about much oxidation, and the use of nitrogen or carbon dioxide is hardly necessary. It is recommended* that "Medicinal cod-liver oil should be bottled preferably in amber-coloured or dark-coloured containers, that the bottles should be as completely filled with oil as possible, and supplied with well-fitting corks of good quality, and that as far as possible instructions should be issued to keep the oil in a dark cool place."

Characters.—Medicinal cod-liver oil is a very pale yellow liquid with only a slightly fishy odour and taste. The acid value should not exceed 1.2 but increases with age, a sample examined by Drummond and Hilditch showing 0.32 when fresh, 0.30 after six weeks, 0.40 after six months, and 0.87 after thirteen months. The iodine value, as may be inferred from the constituents, is high.

Constituents.—The medicinal properties of cod-liver oil are mainly due to vitamins A and D†. The oil consists of glycerides of unsaturated (about 85 per cent.) and saturated (about 15 per cent.) acids. In the unsaturated group, which includes palmitoleic, oleic, linoleic, gadoleic, and clupanodonic acids, the acids possess 14, 16, 18, 20, or 22 carbon atoms, and up to six ethylenic linkings. The saturated acids include myristic acid, $C_{13}H_{27}.COOH$, palmitic acid $C_{15}H_{31}.COOH$, and traces of stearic acid. The presence of any quantity of bile acids or of the alkaloids morrhaine and aselline, which are formed by decomposition, indicate an oil unsuitable for medicinal purposes.

Allied Drugs.—Halibut-liver oil (*Hippoglossus hippoglossus*) is very rich in vitamins and is now a commercial article. Many other fish-liver oils resemble cod-liver oil and an account of the saith, hake, ling, skate, and dogfish will be found in the report referred to above.

* Drummond and Hilditch, *E.M.B.*, 35, pp. 96 and 107.

† For details of vitamins, see Barber's *Textbook of Physiology*.

Uses.—Cod-liver oil is principally used for the prevention and cure of rickets.

CETACEUM

Spermaceti ; F. *Spermacéti* ; G. *Walrat*

Source.—Spermaceti is a solid wax obtained from the head of the sperm whale, *Physeter macrocephalus* (Class Mammalia, Order Cetacea, Family Physeteridæ), and the bottle-nosed whale, *Hyperoodon rostratus*. The whales, which are about 20 and 10 metres in length respectively, are found in the Pacific, Indian, and Atlantic Oceans.

Collection and Preparation.—The whales are killed by means of torpedo-like harpoons which explode within the animal. In the head, in front of and above the skull, is a large cavity, known as the "case," containing sufficient crude sperm oil to fill about 10 large barrels. This liquid is removed either by buckets or by pumping. On cooling it deposits about 11 per cent. of spermaceti. The crude deposit is pressed, melted, and strained, and treated with boiling aqueous caustic soda with which any residual oil forms a soap. The spermaceti is then separated, washed, and allowed to cool.

Characters.—Spermaceti occurs in white, translucent, crystalline masses. It has no marked odour or taste. Sp. gr. 0.95 to 0.96. Acid value not more than 1; saponification value, 125 to 136; iodine value, 3 to 4.4. Melting-point, 46° to 50°.

Spermaceti is insoluble in water and cold alcohol, but soluble in ether and chloroform. It dissolves in 50 parts of hot alcohol (in which adulterants such as stearin, tallow, and paraffin wax are insoluble), but separates on cooling.

Constituents.—Spermaceti consists chiefly of cetyl palmitate, $C_{15}H_{31}.COOC_{16}H_{33}$. Small proportions of other esters are present. It may be saponified by means of boiling *alcoholic* potassium hydroxide, and cetyl alcohol, $C_{16}H_{33}OH$, may then be separated from the soap. Cetyl alcohol forms colourless crystals, melting at 49.5°.

Uses.—Spermaceti is used in ointments and as an emulsion.

Ambergris (F. *Amber Gris* ; G. *Graue Ambra*) is a pathological product found in the intestine of the above-mentioned whales or cast by them into the sea. It occurs in streaky,

grey or brown masses weighing up to 100 lb. It is extremely valuable and is used in perfumery as a fixative. The odour is suitably modified by storing for several years before use. Ambergris contains about 25 per cent. of a substance called ambrein.

ADEPS

Adeps, B.P. ; Lard, Prepared Lard ; F. Axonge ou Graisse de Porc ; G. Schweineschmalz

Source.—Lard is the purified internal fat of the hog, *Sus scrofa* (Order Ungulata, Family Suidæ).

Preparation.—For medicinal purposes lard is prepared from the abdominal fat known as “flare.” If this has been salted it must be thoroughly washed (note the official test for absence of chlorides). The fat is comminuted and placed in lead-lined tanks capable of holding several tons. Water is added and the temperature raised by means of steam pipes until the fat melts and floats on the surface. A temperature exceeding 57° should not be used. The melted fat is run off through openings at the side of the tank, strained, and allowed to cool. Further quantities of fat, but of inferior quality, may be obtained by further heating with the addition of acid to “cut” the cell membranes.

Characters.—Lard is a soft, white fat with a non-rancid odour. Acid value not more than 1.2. Lard has a lower melting-point (34° to 41°) and a higher iodine value (52 to 66) than suet. Saponification value, 192 to 198.

Adulteration.—Tests for the absence of moisture, beef-fat, sesame and cotton-seed oils, and chlorides are given in the Pharmacopœia.

Constituents.—Lard contains approximately 40 per cent. of solid glycerides such as myristicin, stearin, and palmitin, and 60 per cent. of liquid glycerides such as olein. These fractions are sometimes separated by pressure at 0° and sold as “stearin” and “lard oil” respectively.

Uses.—Lard is used as an ointment base. It is somewhat liable to become rancid, but this may be retarded by benzoination.

SEVUM

Sevum, B.P. ; *Suet*, Prepared Suet, Mutton Suet ; F. *Suif ou Graisse de Mouton* ; G. *Hammeltalg*

Source.—Suet is the purified internal fat of the abdomen of the sheep, *Ovis aries* (Order Ungulata, Family Bovidæ).

Preparation.—The preparation of suet closely resembles that of lard but a somewhat higher temperature is necessary to melt the fat.

Characters.—Suet is a firmer fat than lard, and melts at 45°. Acid value not more than 2 ; saponification value, 192 to 195 ; iodine value, 33 to 46.

Constituents.—Suet contains about 70 to 80 per cent. of the solid glycerides, stearin and palmitin, and 20 to 30 per cent. of olein.

Uses.—Suet is used in ointments, especially in tropical and subtropical countries.

ADEPS LANÆ

Adeps Lanæ, B.P. ; *Wool Fat*, *Anhydrous Lanolin* ;
F. *Suint de Laine* ; G. *Wollfett*

Source.—Wool fat is a purified fat-like substance prepared from sheep's wool.

Preparation.—As mentioned on p. 125, raw wool contains considerable quantities of "wool grease" or crude lanolin, the potassium salts of fatty acids and earthy matter. Raw lanolin is separated from the washings of the scouring process and purified to fit it for medicinal use. Purification is difficult and the methods used are trade secrets or the subject of patents. In one patented process the raw lanolin is kneaded by machinery in flowing water, dehydrated by heating, centrifuged while hot, and treated with suitable solvents. Finally, it is again kneaded and washed in water, and dried.

Characters.—Purified wool fat is a pale yellow, tenacious substance with a faint but characteristic odour. It is insoluble in water and a high proportion of water may be incorporated with it by melting (m.p. 34° to 40°) and stirring. Soluble in ether and chloroform. Like other waxes, it is not readily

saponified by aqueous alkali but an alcoholic solution of alkali causes saponification. Saponification value, 94 to 106 ; iodine value, 18 to 32 ; acid value not more than 1.

Constituents.—The chief constituents of wool fat are cholesterol and ischolesterol, unsaturated monohydric alcohols of the formula $C_{27}H_{45}OH$, combined with lanoceric, lanopalmitic, carnaubic, and other fatty acids.

Test for Cholesterol.—Dissolve 0.5 G. in 5 ml. of chloroform, add 1 ml. of acetic anhydride and two drops of sulphuric acid ; a deep green colour is produced.

Uses.—Wool fat is used as an emollient base for creams and ointments.

GELATINUM

*Gelatinum, B.P. ; Gelatin ; F. Gélatine, Grenatine ;
G. Weisser Leim, Gallerte*

Source and Preparation.—Gelatin is obtained by treating certain animal tissues, particularly skin and bones, with hot water so as to convert the collagens into gelatin. The solution obtained is coloured and odorous and requires careful purification to fit it for medicinal use. In the case of glue the purification processes described below are omitted,* and other types of animal tissue may be used.

Preliminary Treatment. 1. *Skins.*—The trimmings of skin which are unsuited to the manufacture of leather are treated with a solution of caustic soda and excess of slaked lime for about 10 to 30 days. This treatment saponifies or emulsifies the fat, produces partial bleaching, and prevents putrefaction. The material is then thoroughly washed.

2. *Bones.*—In this case purification involves the removal of fat and mineral matter, and is performed by Soxhlet extraction with an organic solvent followed by prolonged treatment with dilute acid. Dilute hydrochloric acid (8 to 10 per cent.) or sulphurous acid is commonly used, the latter being useful for its bleaching action. The defatted and decalcified material is then thoroughly washed.

Extraction.—When the collagen of skins or bones, which appears to be the anhydride of gelatin, is heated with water gelatin passes into solution. Long boiling, however, not only causes hydrolysis but considerable darkening of colour. The material is therefore treated at 185° F. (85° C.) with successive quantities of water. The first extraction yields the purest gelatin.

* For further details on the preparation of gelatin and glue, see Bennett's *Animal Proteins*, pp. 220-259.

Purification.—This involves :

- (i) *clarification*, electrolytes being added to cause flocculation of the impurities, which are then separated by sedimentation and filtration ;
- (ii) *decolorisation* by filtration through sand, kieselguhr, animal charcoal, wood pulp, alumina or other substances ; and
- (iii) *bleaching* by reducing agents such as sulphurous acid or by oxidising agents.

Evaporation.—The weak gelatin sol (3 to 9 per cent.) obtained by the above operations is concentrated until it sets to a stiff gel on cooling (20 to 55 per cent.). It is important to concentrate rapidly but at as low a temperature as possible. Multiple-effect evaporators are now widely used. If evaporation is stopped at about a 20 per cent. sol., the resulting gel must be further dried in sheds. The liquid is allowed to set in shallow vessels ($\frac{1}{4}$ to $\frac{1}{2}$ inch deep) or in larger boxes. It is then placed on network frames which are passed through a drying tunnel with air at about 21°. The final drying takes about four days and the finished product still contains about 10 to 18 per cent. of water.

Characters.—Sheet gelatin prepared as above may be cut into strips or made into a granular powder. Gelatin is colourless or pale yellow, translucent, and has little odour or taste. It is insoluble in cold water but absorbs a considerable volume of liquid ; it dissolves on heating and a 2 per cent. solution forms a jelly on cooling. Gelatin is precipitated from solution by *solution of tannic acid* or *solution of trinitrophenol*. When heated with soda lime, ammonia is evolved (distinction from agar). It is rendered insoluble by formaldehyde, or potassium dichromate solution followed by exposure to light. The gelatinising power of gelatin is reduced by long boiling.

Constituents.—Official gelatin consists mainly of gluten, a nitrogenous substance which gives the chemical tests mentioned above. Gelatin prepared from cartilage contains chondrin, and is excluded by the official requirement that the drug shall give no precipitates with acids (except tannic acid) or with alum, lead acetate, etc. Glue is of a similar chemical nature but contains colouring matters.

Uses.—Gelatin is used in the preparation of suppositories, capsules, pill-coatings, etc.

Allied Drug.—*Isinglass* is the dried swimming bladder of many species of fish, particularly of the sturgeons (*e.g. Acipenser huso*) found in South Russian rivers and the Black and Caspian Seas. The bladders are opened, washed, deprived of the outer membrane, and dried. Isinglass resembles gelatin in its properties. It consists chiefly of collagen and is used in the preparation of court plaster.

MOSCHUS

Musk, Deer Musk ; F. Musc ; G. Bisam

Source.—Musk is a dried secretion obtained from the preputial follicles of the musk deer, *Moschus moschiferus* (Order Ungulata, Family Cervidæ). The musk deer is about 50 cm. in height and of a greyish-brown colour. Most mammals have some portion of their skin modified for the secretion of

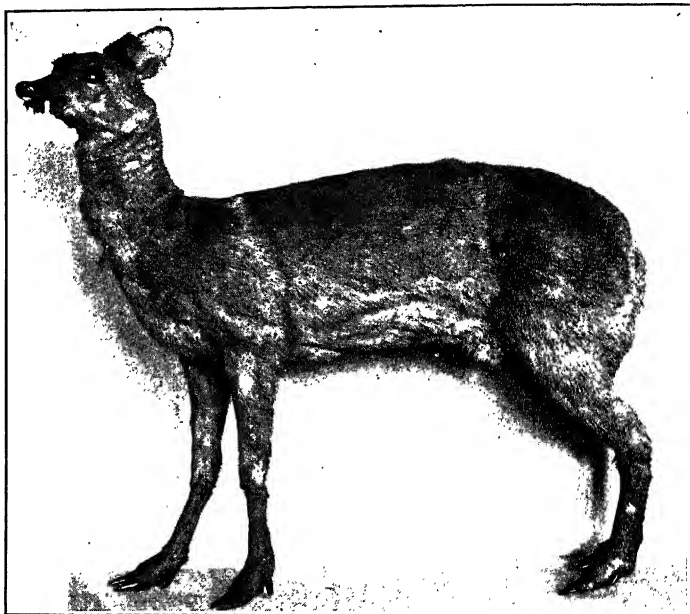


FIG. 225.—A male musk deer in the Natural History Museum, Wollaton Hall, Nottingham. The musk pod is clearly shown. (Photo. Sutcliffe, by kind permission of the Curator.)

odorous substances, but in the adult male musk deer a distinct pouch or sac with a narrow tubular orifice is provided for this purpose between the navel and prepuce. This contains a considerable quantity of dark brown secretion, which may be discharged by the action of a compressor muscle which surrounds it.

Collection and Preparation.—The deer are found in the highlands of Central and Eastern Asia (the Chinese provinces Tzechuen and Yun-nan), Tibet, Assam, Nepaul, and Kashmir). Most of the musk which is exported is sent to Shanghai by routes similar to those taken by rhubarb and is known as Tonquin musk.* Other commercial varieties are Yunan, Assam, and Nepaul musks, which are mainly exported *via* Calcutta.

The animals are snared or shot, the sacs cut off with a certain amount of abdominal skin, and dried. The abdominal skin is afterwards trimmed off, except for a small portion surrounding the orifice. Musk is often adulterated by the collectors and by the Chinese merchants through whose hands it passes. In China and again in London the "pods" are carefully examined and divided into three grades or piles, pile I consisting of good class pods, pile II of those of inferior quality or doubtful purity, and pile III of very poor or obviously adulterated pods.

Each pod is wrapped in paper and packed in metal-lined boxes or in flat tins containing two "cattys" ($43\frac{1}{2}$ oz. or about forty to fifty pods).

Characters.—*Tonquin musk pods* are circular or slightly oval in outline and measure 5 to 7 cms. in diameter and 2 to 3 cms. in thickness. The upper surface, as attached to the animal, is flatter than the side bearing the orifice. The remains of the outer skin usually extend about 2 cms. round the orifice in all directions and bear radiating, bristly hairs of a greyish or brownish colour. Within this hairy skin lies an inner, often glistening "blue skin." Some pods are found which have not had the abdominal skin trimmed off, these being known as "old style" or "natural-skin" pods. Musk pods weigh about 30 G. each and, if of good quality, contain about half their weight of musk. The latter is at first unctuous or semi-liquid, but when allowed to dry in the air forms reddish-brown fragments (grain musk). It usually contains hairs, bacteria, and fungal hyphæ. Musk has a bitter taste and a strong, characteristic odour which is apparent even at great dilutions.

Yunan musk approaches the Tonquin in quality. The pods are more globular, however, and the fact that the orifice is depressed and that there are two protuberances near the

* The name Tonquin is somewhat misleading, as no musk is actually produced in Tong-king, and any passing through this province would probably come from Yun-nan.

margin causes them to be known as "pig-faced" pods. *Assam* and *Nepaul* pods are globular and weigh only about $\frac{1}{3}$ oz. The contents are usually of fair quality. These varieties are often imported without the sac and may be distinguished by their odours and colours, *Nepaul* being reddish-brown and *Assam* blackish.

Constituents.—Musk yields, on steam distillation, about 1.4 per cent. of a dark brown volatile oil. From this Walbaum (1906) isolated muskone, $C_{16}H_{30}O$, a cyclic ketone containing a closed chain of fifteen carbon atoms and closely related to civetone (see below). This is the chief odorous constituent, other substances present being moisture, fat, proteins, resins, and inorganic matter.

Most of the synthetic musks, e.g. musk-xylene, ketone-musk, and musk-ambrette, are entirely different from muskone in chemical nature although capable of replacing musk to some extent in perfumery. Within recent years, however, *cyclopentadecanone*, $C_{15}H_{28}O$, has been marketed as a more satisfactory, though much more expensive, musk substitute. *Cyclopentadecanone* differs from muskone only in the absence of a methyl group.

Uses.—Musk was formerly used in medicine but is now seldom prescribed. It is of considerable importance in perfumery.

Allied Substances.—*Civet* is prepared from various species of *Viverra* (Order Carnivora, Family Viverridæ), particularly the African civet or "civet cat" and Indian civets. The animals are kept in cages and the secretion collected from the perineal follicles with a spoon or spatula. It is usually imported in horns. It is largely used in perfumery and owes its odour to an unsaturated cyclic ketone, *civetone*, the molecule of which contains a closed chain of no fewer than seventeen carbon atoms.

Castor consists of the dried, preputial follicles of the beaver, *Castor fiber* (Order Rodentia, Family Castoridæ), collected in Canada or Siberia. It contains a musk-like secretion which is used in perfumery.

American musk is a product of the muskrat or musquash, *Fiber zibethicus*, and is sometimes used instead of true musk although much inferior to it.

PART V

PHYSICAL AND CHEMICAL METHODS OF
DRUG ANALYSIS

CHAPTER XXIV

TESTS FOR PLANT-PHENOLS

BY A. H. WARE, PH.C.

PHENOLIC substances are of widespread occurrence in plants, and they give a great variety of response to reagents. Tests for plant-phenols therefore afford a most useful means of approach to the identification of drugs by chemical methods. The tests employed depend very largely on the use of iron reagents, formaldehyde, alkalis, and nitrous acid. Considerations of space will only allow a description of a necessary minimum of the more useful tests for detecting and distinguishing between the more important plant phenols or classes of phenols. The methods of testing, the results to be looked for, and lists of phenol-containing drugs are given below under the following headings :—

1. General tests for tannins.
2. Classificatory tests for tannins.
 - (i) Phlobatannins.
 - (ii) Pyrogallol tannins.
 - (a) Ellagitannins.
 - (b) Gallitannins.
3. Pesudotannins.
4. Pyran-phenols.
5. Anthoxanthins (γ -pyrone phenols).
6. Emodins or emodin-yielding compounds.
7. Scopoletin (β -methylæsculetin).
8. Phenolic resins and phenols in volatile oils.
9. Phenolic alkaloid.

1. General Tests for Tannins

A large number of useful tests for tannins have been published, but none are so specific, or so generally useful for routine work, as the two given below. Some exception to

this statement must be made in the case of the goldbeaters' skin test, but this is not described because of the length of time it takes to work and because the interpretation of the results given by it requires considerable experience.

Tests with Phenazone.—To 5 ml. of an aqueous decoction of the drug (or well-diluted commercial extractive) add 0.5 G. of acid sodium phosphate; warm, cool and filter. To the filtrate add a sufficient quantity of 2 per cent. solution of phenazone.* **Results:** All tannins are almost completely precipitated. The precipitate is usually bulky and often coloured.

Tests with an Iron Complex.—Mitchell's reagent (ferrous sulphate 0.1 G. and Rochelle salt 0.5 G. in 100 ml. of water), or a 0.25 per cent. solution of Iron and Ammonium Citrate B.P. may be used. 5 ml. of the reagent is added to 5 ml. of the solution to be tested, and is followed by 0.5 to 1.0 G. of sodium acetate.† The mixture is then boiled, cooled, and again, if necessary, boiled. **Results:** A purple, violet, or blackish bulky precipitate is obtained if tannin be present, which is insoluble in hot water, alcohol, or aqueous ammonia. A brown precipitate is given by some yellow plant colouring-matters. A purple, violet, or blue solution, or filtrate, indicates the presence of gallic acid, pseudotannins or pyran-phenols.

2. Classificatory Tests for Tannins

(i) **Phlobatannins.**—The following test appears to be quite specific for distinguishing phlobatannins from any other substances which are likely to be present in plant extractives in appreciable quantities.‡

* This test is more specific than the cinchonine test. As an indication of the superiority of the test over the one using a cinchona alkaloid, compare the behaviour of the phenazone phosphate reagent with a diluted extract of liquorice and the same extract with a solution of cinchonine or quinine hydrochloride. The latter precipitate glycyrrhizic acid while the phenazone reagent does not.

It should be noted that most phlobatannin extractives made with alcohol yield copious precipitates on dilution with water, and especially in the presence of an electrolyte such as acid sodium phosphate. Indeed, little or no tannin may remain in solution. If, however, the precipitated phlobaphene be washed, and then percolated on the paper with *very dilute* aqueous ammonia, the filtrate obtained will give the characteristic response to the iron-complex test.

† The B.P. Strong Solution of Ammonium Acetate may be used instead, but not commercial ammonium acetate, which is sometimes strongly acid.

‡ Phloroglucinol, orcinol, and resorcinol give similar results, but are unlikely to occur in plant extractives in any appreciable quantity.

Test with Formaldehyde.—To 6 ml. of the extractive (aqueous or, if alcoholic, well diluted with water) add 3 drops of 40 per cent. solution of formaldehyde and 6 drops of 10 per cent. hydrochloric acid. Raise to the boiling point, cool, and, if necessary, again raise to the boiling point and cool, but in any case do not continue boiling for more than a minute. It is also important that the acidity should not be *markedly* greater than that indicated, but slight variations are unimportant. Wash the precipitate successively with hot water, warm alcohol, and warm 5 per cent. aqueous potassium hydroxide. **Results :** A bulky precipitate is given which leaves a coloured residue after the prescribed treatment.*

Drugs.—For a list of drugs containing phlobatannins, see Table 1, p. 679.

(ii) **Pyrogallol - Tannins (Non - Phlobatannins).**—Pyrogallol tannins fall into two subclasses (ellagitannins and gallitannins), dealt with below, but first a test apparently quite specific for the whole class will be described.

Modification of Iron-Complex Test.—To about 6 ml. of the decoction or well-diluted alcoholic extractive (which need not be filtered) add 1 drop of 33 per cent. acetic acid and 1 G. of sodium potassium tartrate. Warm and filter off any precipitate. Wash this, if any, and let the washings mix with the previous filtrate (neglect any cloudiness at this stage). Add the iron reagent described in the previous test for tannins until there is no further intensification of colour, and boil. **Results :** A purple, violet or blackish precipitate is obtained, which is insoluble in hot water, alcohol, or aqueous ammonia.†

Test to Distinguish between Ellagitannins and Gallitannins.—To 10 ml. of a decoction of the drug‡ add a few crystals of sodium nitrite. Heat *gradually* nearly, but not quite, to boiling. If no characteristic colour is given, cool,

* Other substances than phlobatannins may be precipitated, but dissolve in one or other of the solvents successively added. Gambir is a notable case in point, for both the catechutannic acid and catechin are precipitated, but the condensation product formed by the latter is washed through by the alcohol and alkali, and if the filtrate is collected, will give a characteristic condensation product if boiled with an *equal quantity of concentrated* hydrochloric acid and three drops or so of the formaldehyde solution.

† Phlobatannins do not precipitate under the conditions given above, but will do so if sodium acetate and a slight excess of ammonia be added.

‡ The decoction should be diluted, if necessary, until it has no *marked* colour but retains a *definite tint* before testing, and if during the heating there is a tendency to the development of an intense brown colour the mixture should be further diluted.

add a little solid acid sodium phosphate, and repeat the heating. Results : A succession of colour changes may often be seen, but in any case the final colour should be green, blue or purple (most frequently an intense green or greenish-blue) if ellagitannin be present.

Probably gallitannin generally accompanies ellagitannin, but it does not interfere with the reaction described above. To detect gallitannin in the presence of ellagitannin is not so easy unless it is in large excess, as in the case of Turkish galls. If a decoction of Turkish galls is poured very gradually into excess (at first) of solution of calcium hydroxide a bluish precipitate is obtained.

Drugs.—For a list of drugs containing pyrogallol-tannins, see Table 2, p. 680.

3. Pseudotannins

Under the name pseudotannins it is convenient to include a number of plant-phenols which do not give the *more specific* reactions for either tannins or pyran-phenols, but resemble the tannins and the more important pyran-phenols with respect to giving with soluble iron salts a purple or violet colour upon the addition of a weak solution of sodium bicarbonate. If, instead of the bicarbonate, ammonia be used in adequate quantity, a deep red colour is produced with sufficiently pure material. Catechinol, a pseudotannin, may be compared with catechol, which gives similar results. The test, however, can be carried out with ammonia on filter-paper as described below in such a way as to give a purple or violet colour and will then often detect smaller amounts of the plant-phenol than any other method.

Test with Ferric Chloride and Ammonia on Filter-Paper.—For this test it is best to use an extractive made with about 48 per cent. alcohol. Pour a little of the solution to be tested on a pad of three small filter-papers. The upper one may be used as a filter and removed. The extractive should tint the paper but not deeply stain it. Now drop into the extractive area two drops of test solution of ferric chloride and then closely contiguous to the iron area, but not touching it, one or two drops of 10 per cent. aqueous ammonia. Results : If tannins, pseudotannins, cyanidin or delphinidin anthocyanes, hæmatoxylin, brazilin or gallic acid * be present there may be

* For the purposes of the qualitative analysis of extractives, gallic acid may be regarded as a pseudotannin.

a succession of colours, but the final colour most in evidence, after the ammonia has diffused into the iron area and more or less evaporated, will be purple or violet (or in the case of tannins sometimes blackish).

Test with Sodium Bicarbonate.—Sodium bicarbonate does not give any marked colour-reaction with either tannins or pseudotannins, but it will do so with pyran-phenols (*q.v.*).

Test with Iron Complex (as described on p. 670). With the exception of hæmotoxylin, which is partially precipitated (giving a blue precipitate and a violet filtrate), neither the pseudotannins nor the pyran-phenols are precipitated, but give a purple or violet solution or filtrate.*

The above three tests, taken together, will detect pseudotannins except in the presence of pyran-phenols. Special methods have to be used in the latter case.

Tests for Individual Pseudotannins and Lists of Drugs containing Them

(*a*) **Gallic Acid.**—For tests with ammonia, etc., see footnote under pyran-phenols (p. 674). Gallic acid is contained in most substances which contain gallic acid tannins.

(*b*) **Catechins and Related Bodies.**—These may be detected as follows :—Dip a match stick or deal shaving into an extractive, which must be of such a dilution that it only gives a slight tint to the wood. Dry the stick and dip it into concentrated hydrochloric acid, removing quickly. Warm it near a flame. If any appreciable quantity of catechin or related body be present, a deep magenta-purple or purple-violet stain is given to the match stick (compare with resorcinol and phloroglucinol). Catechins or related bodies appear to be present in many phlobatannin materials.

(*c*) **Chlorogenic Acid** (so-called **Caffeotannic Acid**).—The test for this substance, in which a little ammonia is added to an aqueous extractive and the mixture on exposure to air develops a green colour, is well known. It is contained in maté, coffee and nux vomica seeds.

(*d*) **Ipecacuanhic Acid.**—This substance, which is found in

* It must be noted that pseudotannins (especially the catechins and gallic acid) frequently accompany tannins, so that both a coloured precipitate and a coloured filtrate may be given. Excess of reagent must be used if a precipitate is obtained and pseudotannins or pyran-phenols are to be tested for.

ipecacuanha roots, differs from other plant-phenols which give the catechol type of reaction with iron in that it is not precipitated by neutral lead acetate. The test may be performed on the official liquid extract of ipecacuanha diluted with water. To this solution add excess of lead acetate, filter on to a pad of absorbent paper, and add ferric chloride solution. The addition of ammonia is unnecessary as the lead acetate adjusts the pH in such a way that the purple colour is given.

4. Pyran-Phenols

For the following tests use fresh extractives made with water slightly acidified with acetic acid. Anthocyan-containing materials give a pink solution, but logwood (hæmatoxylin) and sappan (brazilin) give a yellow.

Test with N/50 Sodium Bicarbonate or Carbonate.*—Add the alkaline solution very gradually to a sufficiently strong extractive. Results : Brilliant colours are given to the reagent by all pyran-phenols, but with the cyanidin and delphinidin anthocyanins there is a remarkable succession of colours, viz. with increasing alkalinity, pink, red, purple, violet, blue, and green, in the order named (with weaker extractives there may be a jump from the purple to the green). With hæmatoxylin and brazilin (decoctions of logwood and sappan may be used) the changes do not go beyond the purple.†

* Sodium carbonate (or bicarbonate) is preferable to the ammonia, solution of calcium hydroxide, or stronger alkalis recommended in some text-books, for the following reasons, viz. :—

- (a) Because with stronger alkalis it is more difficult to get the full succession of colours shown by the anthocyanins.
- (b) Because ammonia and the fixed alkalis, if used in excess, tend to destroy the pyran-phenols with the production of either a yellow (anthocyanins) or brown colour (hæmatoxylin or brazilin).
- (c) Because under appropriate conditions, which may actually be obtained in testing for pyran-phenols, ammonia, solution of calcium hydroxide, or the fixed alkalis may give similar results with gallic acid, gallotannin, or certain other phenols belonging to the classes previously dealt with. This may be seen by pouring a solution of gallic acid or gallotannin into a solution of calcium hydroxide, with *gentle* agitation, using preferably a white dish rather than a test-tube. Also note the behaviour of gallic acid or gallotannin and that of a decoction of galls when these are poured on pads of filter-papers, the moist area treated with two drops of 10 per cent. aqueous ammonia and allowed to stand. Similar characteristic colour-reactions are given in each case.

† Hæmatoxylin and brazilin, or the drugs from which they are obtained, may be readily distinguished from one another by adding to the test mixture at the purple stage a little alum. The logwood extractive then gives a rich violet whilst the sappan still only shows a purple colour.

Test with (" Normal ") Lead Acetate.—This reagent gives characteristically coloured precipitates in all cases. With anthocyanins, unless due care be taken, the precipitate tends to be green (as with alkalis).

Test with Alum.—Some extractives containing pyran-phenols, notably logwood and cyanidin and delphinidin anthocyanins, give with alum a considerable intensification of colour, *e.g.* pink to purple or purple to violet, etc. With brazilin or pelargonidin anthocyanins much less, if any, colour change is shown.

5. Drugs containing Anthoxanthins (γ -Pyrone Phenols)

In the absence of interfering substances anthoxanthins can readily be distinguished by the following characters. Tested in sufficiently strong extractive they give a yellow colour with alkalis, and a green or brown colour with ferric chloride, modified to a deep brown colour or precipitate on adding ammonia, sodium bicarbonate, or sodium acetate. The iron-complex test never gives with an anthoxanthin a blue, violet, or definitely purple colour. Anthoxanthins give a definitely yellow precipitate with lead acetate, even in alcoholic extractive. The presence of tannins or anthraquinone phenols may mask all these results, but in such cases their presence may often be indicated by boiling a little of the extractive, diluted if necessary, in a white dish with a little dilute sulphuric acid. If the dish be occasionally agitated from side to side a yellow film will appear above the fluid on the side of the dish. If the fluid be made to pass over this film before charring occurs, the colour is destroyed (anthoxanthins form salts with acids which are hydrolysed by water).

Some extractives (but unfortunately few of those used in medicine give a very good result), for example, aqueous extractives of wood spurge or alcoholic extractives of old fustic (a wood used in dyeing khaki), and tinctures of orange and lemon (due in both cases to hesperitin), will give a rich pink colour if treated with sufficient hydrochloric acid and a little pure zinc or magnesium, and warmed. This is due to the reduction of the anthoxanthin by nascent hydrogen with production of an anthocyan or anthocyan-like substance.

Anthoxanthins are the most widely distributed of all plant-phenols, and are probably always present in or near the inflorescence of flowering plants. They are much less frequently

present, in any appreciable quantity, in woods and seeds ; but to this generalisation there are many exceptions, *e.g.* old fustic and quebracho woods and fenugreek seeds.

It will be noted that in many drugs tannins are accompanied by anthoxanthins (compare lists), but it should also be noted that the so-called tannins in many drugs (*e.g.* coca leaves, arnica flowers, and santonica) are probably anthoxanthins (see also pseudotannins in this connection).

6. Emodins and Emodin-Yielding Compounds

General Test.—The whole group of drugs which contain emodins or closely related bodies is fairly well distinguished by the familiar test in which the powder is triturated with carbon tetrachloride (or other suitable solvent), or the extractive shaken out with such a solvent ; the organic solvent layer is separated, and shaken with an equal volume or less of aqueous 10 per cent. ammonia. **Results :** The organic solvent solution prior to shaking with ammonia is yellow. After shaking the ammonia becomes distinctively coloured, the colour usually varying from pink to carmine-purple in intensity according to the amount of emodin reacting, but is less distinctive with some aloes, notably Cape, in which case it may be brown.

Special Tests.—(a) **Rhubarb** (the official at least) is well distinguished by the characteristic pseudotannin or tannin response given to the test on filter-paper with iron and ammonia, two or more of the colours, green, blue, violet, or purple being produced and either violet or purple persisting after the diffusion of the ammonia into the iron area.

(b) **Aloes** as a class are distinguished by the tests with borax and bromine water given in the Pharmacopœia, of which the borax test is much the more specific, bromine water giving precipitates with an enormous number of extractives other than aloes, notably all phlobatannin and most alkaloidal extractives. Indeed, not to give a precipitate with bromine water is more distinctive than to give one, *e.g.* a negative response to bromine water is a characteristic of typical pyrogallol tannin extractives, which is useful in some cases. The writer finds that a much more specific *class* reaction for aloes is given as follows :—Dissolve a little aloes in 10 ml. of water. Add 0.5 ml. of No. 1 Solution for Fehling's test (containing CuSO_4 and a little H_2SO_4). Heat to boiling and add 1 or 2

drops of 10 vol. solution of H_2O_2 . Quickly boil again and dilute with an equal quantity of 6 per cent. acetic acid. An intense wine-purple colour is given, bearing much dilution with water.

To distinguish between individual kinds of aloes nitric acid is a most useful reagent. Either the method of the Pharmacopœia may be used, or the older one of stirring the aloes in powder with strong nitric acid on a tile. In using this method from two to five minutes must be allowed for the green given by Cape aloes to develop, but even then it is quicker than the full process of the Pharmacopœia.

The nitrous acid test for isobarbaloin is by far the most specific test for aloes containing it, viz. Curaçao aloes (and aloin prepared from it) and Cape aloes. Dissolve a small quantity of the aloes or aloin in from 5 to 8 ml. of water by the aid of heat. Cool and filter. Add a few small crystals of sodium nitrite and two drops or so of 33 per cent. acetic acid. Shake, in the cold, for one or two minutes. **Results:** A rich pink to carmine is given by Curaçao aloes and aloin obtained from this variety; Cape aloes gives a poorer colour; Socotrine and Zanzibar give no characteristically distinctive colour. In fact, *worked as described*, the test appears to be quite specific for isobarbaloin drugs. The colour persists for a long period, and thus distinguishes this class of drug from the ellagitannin drugs, which may give a *temporary* pink or purple, passing on to a violet, blue, or green under certain conditions (see ellagitannins), colours which are not given under the conditions named by aloes.

7. Scopoletin (β -Methylæsculetin)

If drugs containing scopoletin are extracted with chloroform and the separated chloroformic solution shaken with very dilute ammonia solution a greenish-blue fluorescence is produced in the ammoniacal layer. A rich fluorescence is given by gelsemium and Mexican scammony, poorer results by the bark of *Prunus serotina*, belladonna root, jalap, and the root of *Convolvulus Scammonia*.

8. Phenolic Resins and Phenols in Volatile Oils

Many resins and volatile oils contain phenolic bodies and consequently will give colour-reactions to iron, oxidising agents, etc. Amongst these are the balsams and balsamic resins; the

umbelliferous oleo-gum-resins and sumbul root; guaiacum wood and resin; red sanders wood; alkanet root; the volatile oils of cloves, cinnamon, and gaultheria. These may be tested in alcoholic solution or extract on filter paper with alcoholic ferric chloride, nitrous acid (sodium nitrite in 45 per cent. alcohol followed by a few drops of acetic acid), or ammonia.

(a) **Guaiacum extractives** give a brilliant blue to both the ferric chloride and the nitrous acid test.

(b) **Alkanet root extractives** give a brilliant blue to ammonia changed to red by acid.

(c) **Red sanders wood extractives** give a very transient rich violet to ferric chloride, and a similar transient colour (purple or violet) to ammonia. To sodium nitrite it gives a rose-pink, becoming greenish on adding acetic acid.

(d) **Ammoniacum** gives a pale purplish (in water) or purplish-brown (in alcohol) to ferric chloride, and is distinguished from galbanum or asafetida by the negative response to the tests for free or combined umbelliferone.

(e) **Drugs containing or yielding umbelliferone.**—Sumbul and galbanum contain free umbelliferone, and asafetida yields umbelliferone if a tincture is warmed with hydrochloric acid. Sumbul and galbanum also give other distinctive results when warmed with hydrochloric acid.

Method of Testing.—An alcoholic extractive or alcohol-diluted commercial tincture is used. It should not be too strongly coloured. About 5 ml. of this is gradually heated to boiling-point with about 10 drops of concentrated hydrochloric acid (but not enough to cause precipitation of resin). Any colour reaction is noted and the mixture poured into a sufficient quantity of alcoholic ammonia (alcohol with a *little* strong solution of ammonia). The final admixture should be quite clear and only slightly tinted when viewed by transmitted light. A blue fluorescence should be shown by reflected light. The experiment is repeated without the preliminary warming with hydrochloric acid.

Results: Sumbul and galbanum give beautiful colours to the preliminary treatment with hydrochloric acid. These colours may be one or more of the following, viz. green, blue, violet or purple, and sometimes all of them in succession in the order named, the exact result depending upon the strength of the tincture, the proportion of acid and the length of the heating. Sumbul, galbanum, and asafetida all give a rich

fluorescence after the treatment with hydrochloric acid upon pouring into alcoholic ammonia. Sumbul and galbanum give more or less fluorescence without the preliminary treatment with hydrochloric acid, but asafetida does not.

9. Phenolic Alkaloid (Morphine)

Opium does not contain any very appreciable quantity of any plant-phenol belonging to the classes already discussed, but its chief constituent, the alkaloid morphine, is a phenol. In a sufficiently concentrated solution of the right *pH* morphine gives a good colour-reaction with ferric chloride. This cannot be obtained with opium extractives because when these are of such a strength and *pH* that a blue or green colour might be expected, other substances, notably meconic acid, interfere. The well-known reddish or purplish reaction given by diluted opium extractives to ferric chloride, the colour not being destroyed by adding dilute sulphuric acid, is due to the non-phenolic body, meconic acid. If, however, a little opium extractive be diluted to show only a yellowish tint, it will develop, after treatment with nitrous acid followed by ammonia, an intense brownish-red or reddish-brown colour. This colour production is mainly due to the phenolic character of the morphine. Most plant-phenols will give similar or other characteristic colours to this test. The nitrous acid is furnished by adding a few small crystals of sodium nitrite and then a few drops of acetic acid and warming. This test is useful as a general test to distinguish a number of plant substances giving negative or very feeble responses, and which therefore are unlikely to contain any appreciable amount of plant-phenol. We therefore conclude by giving a list of some of the more important of such drugs (see Table 9).

Table I
Drugs Containing Phlobatannins

- (a) **Barks.**—Cinnamon, wild cherry, cinchona, willow, acacia, oak* and hamamelis.
- (b) **Roots and rhizomes.**—Krameria and male fern.
- (c) **Seeds.**—Cocoa, guarana, kola and areca.
- (d) **Leaves.**—Hamamelis* and tea, especially green tea.*
- (e) **Extracts and dried juices.**—Catechu, acacia and mangrove cutches, East Indian kino, butea gum and eucalyptus kino.

* Oak bark also contains a little ellagitannin, and tea a little gallitannin, Hamamelis contains two tannins, the more important being a gallitannin.

Table 2

Drugs Containing Pyrogallol-Tannins (Non-Phlobatannins)

- (a) **Ellagitannins.**—Pomegranate rind, pomegranate bark, myrobalans, Turkish galls, eucalyptus leaves, kousso, some Australian kinos and oak bark.*
- (b) **Gallitannins.**—Rhubarb, cloves, red rose petals, bearberry leaves, Chinese galls and logwood.
- (c) **Gallitannins and Phlobatannins.**—Hamamelis leaves * and bark, the bark of *Acacia arabica*, some kinos and tea.*

Table 3

Drugs Containing Pseudotannins

- (a) **Gallie Acid.**—Rhubarb and most materials which contain gallitannins.
- (b) **Catechins.**—Catechu, acacia cutch, many Australian kinos, cocoa, guarana and many other drugs containing phlobatannin.
- (c) **Chlorogenic Acid.**—Maté, coffee (particularly unroasted) and nux vomica (a small quantity only).
- (d) **Ipecacuanhic Acid.**—Ipecacuanha.

Table 4

Drugs Containing Pyran-Phenols

Logwood,† sappan,† red rose petals,† red poppy petals, buckthorn berries and probably embelia.

Table 5

Drugs Containing Anthoxanthins

- (a) **Leaves.**—Bearberry, buchu, coca, hamamelis, digitalis, jaborandi and stramonium.
- (b) **Flowers.**—Arnica, cloves, elder, grindelia, kousso, red rose petals and santonica.
- (c) **Fruits and Seeds.**—Caraway, fenugreek, lemon and orange peels.
- (d) **Roots and Rhizomes.**—Gentian, liquorice, picrorhiza, podophyllum and senega.
- (e) **Extract.**—Catechu.

Table 6

Drugs Containing Emodins and Emodin-Yielding Compounds

Various species of *Rheum*, *Rhamnus*, *Cassia* and *Aloe*. For specific tests for rhubarbs and aloes, see p. 676. Also araroba and chrysarobin (see p. 480).

* Oak bark also contains a little phlobatannin, and tea a little gallitannin. Hamamelis contains two tannins, the more important being a gallitannin.

† These drugs also contain tannin.

Table 7

Drugs Containing Scopoletin

Gelsemium, ipomœa, jalap, the root of *Convolvulus Scammonia*, belladonna root and wild cherry bark.

Table 8

Drugs Containing Phenolic Resins and Miscellaneous Phenols

- (a) **Umbelliferone Present.**—Galbanum (free), sumbul (free), asafetida (combined).
- (b) **Umbelliferone Absent.**—Guaiacum, alkanna root, red sanders wood and ammoniacum. For specific tests, see p. 678.
- (c) **Phenolic Alkaloid.**—Morphine.

Table 9

Drugs Containing Little or No Plant-Phenols or Plant-Phenols of a Non-Typical Kind

- (a) **Absent.**—Alstonia, barberry, cascarilla and quillaia barks; quassia wood; aconite black hellebore, calumba, hydrastis, serpentary and squill; cubebs and strophanthus.
- (b) **Non-Typical.**—Capsicum, ginger and myrrh.

CHAPTER XXV

FLUORESCENCE ANALYSIS

DURING recent years the use of filtered ultra-violet light has steadily increased in analytical work, and the results of the many workers in this field have now appeared in book form.* As with everything new, there has perhaps been a tendency to over-estimate the value of fluorescence analysis in certain cases. Provided, however, that the evidence obtained is taken in conjunction with that derived from other sources, there is little doubt that by improving the present technique fluorescence analysis will find a permanent position in the work of pharmacognosists and others.

Fluorescence.—Many substances, for example, quinine solution, when suitably illuminated, emit light of a different wavelength or colour from that which falls on them. This emitted light, which we call fluorescence, ceases when the exciting light is removed. Fluorescence thus differs from phosphorescence, in which phenomenon the substance continues to emit light after the removal of the exciting light.

Analytical tests based on fluorescence *in daylight* are not much used, as they are usually unreliable, owing to the weakness of the fluorescent effect. An exception to this is the well-known umbelliferone test (p. 678), which is often applied to ammoniacum, galbanum, and asafetida. A strongly fluorescent solution of umbelliferone can be prepared by boiling galbanum with acid and filtering into excess of alcoholic ammonia. Other fluorescent solutions which can easily be prepared are quinine (in dilute acid), æsculin (by infusing horse chestnut bark), chlorophyll (from nettle or parsley leaves), β -naphthol (dissolved in alkali), and aqueous solutions of the dyes eosin and fluorescein.

* *Fluorescence Analysis in Ultra-Violet Light*, by J. A. Radley and J. Grant, published by Chapman and Hall, Ltd. The information contained in this chapter is partly derived from the above book and partly from three articles by the author, which appeared in the *Pharmaceutical Journal*, 1930, pp. 162, 187, 264.

Nature of Rays Producing Fluorescence.—When a beam of sunlight falls on a glass prism it is split up into the different colours or wave-lengths of which it is composed, forming what appears to the eye to be a continuous spectrum. The waves of visible light are extremely small, although not so minute as those of the ultra-violet region. They vary from about 8,000 Å.U. at the red end of the spectrum to 4,000 Å.U. at the violet end.* If a spectrum be produced in this way, the effect of different wave-lengths or colours on fluorescent substances can be investigated. In order to examine the effect of rays in the ultra-violet as well as in the visible region, the prisms used must be of pure quartz, as the short waves of ultra-violet light are not readily transmitted by glass, but will pass through quartz.

The fluorescent substance to be examined, if a liquid, is best contained in a test tube of non-fluorescent glass or quartz. This is moved through the spectrum from the infra-red end into the ultra-violet region. No fluorescence is observed in the longer waves, and the region in which fluorescence is first observed differs for different fluorescent substances. Thus, if we use two tubes, one containing eosin and the other quinine solution, we find that the eosin starts to fluoresce in the orange region, but quinine remains non-fluorescent until the violet is reached. It has been found that fluorescein commences to fluoresce at 5,420 Å.U., eosin at 5,890 Å.U., and "naphthalin roth" at 6,320 Å.U. A very important generalisation was made by Stokes in 1852 to the effect that "in fluorescence the fluorescent light is always of greater wave-length than the exciting light." This statement is known as Stokes' Law of Fluorescence.

Experience shows that light rich in short wave-lengths is very active in producing fluorescence. For this reason strong ultra-violet light (such as can be obtained from a tungsten arc or mercury-vapour lamp) produces fluorescence in many substances which do not visibly fluoresce in daylight. Fluorescence analysis by means of the Analytic Quartz Lamp is based on this fact.

The Apparatus.—The "Hanovia Muir" Analytic Lamp, illustrated in Figs. 226 and 227, is a useful type of instrument for fluorescence analysis. In essentials it consists of a box

* Light waves are expressed either in millimicrons ($\mu\mu$) or in Angström Units (Å.U.). 1 millimicron is the one-millionth part of a millimetre and an Angström Unit is one-tenth part of a millimicron.

enclosing a quartz mercury arc tube, some of the rays from which pass through a Wood's glass filter to the substance under examination. This filter transmits only invisible ultra-violet rays ; its characteristics are illustrated in Fig. 228.

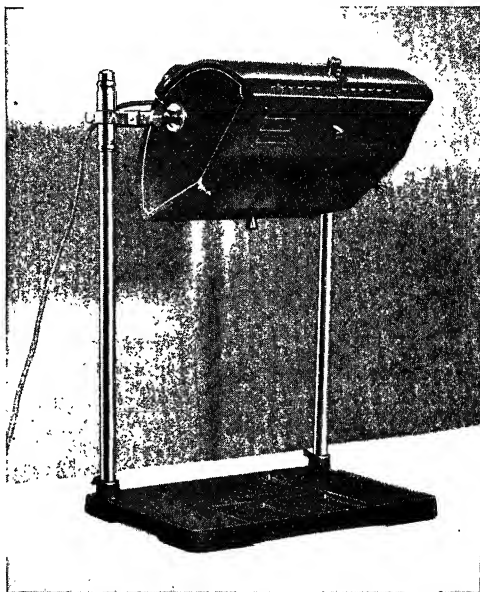


FIG. 226.—The Hanovia Muir Analytic Lamp (table model). The ultra-violet rays are generated from the arc tube within the housing ; the Wood's filter is seen pointing obliquely downwards (Hanovia, Ltd.).

The arc tube is a transparent evacuated tube of fused quartz, having at each end an electrical connection to an internal electrode. The electrodes are coated with electronic-emitting substances, so that when current is applied a discharge is set up in the gas filling. Inside the tube is a minute amount of mercury, which quickly vaporizes in the discharge and builds up to a high pressure arc having the known characteristics of the mercury arc, see top spectrum, Fig. 228. The arc tube requires a minimum mains pressure of 200 volts for successful operation, and is operated through a stabilizing reactance or

resistance unit for alternating or direct current mains respectively. The arc reaches full intensity within three minutes of starting.

The light from a mercury vapour lamp, like ordinary white light, contains ultra-violet rays. Mercury vapour, unlike sunlight, does not give a continuous spectrum, but the emitted rays are concentrated in separate bands or colours between which the intermediate colours or wave-lengths are almost entirely absent (see Fig. 228, 1). Some of these bright bands occur in the visible region of the spectrum and some in the ultra-violet. The shorter waves, from $1,870 \text{ \AA.U.}$ downwards, cause ozonisation of the air through which they pass, and a smell of ozone is always noticed when the lamp is in operation.

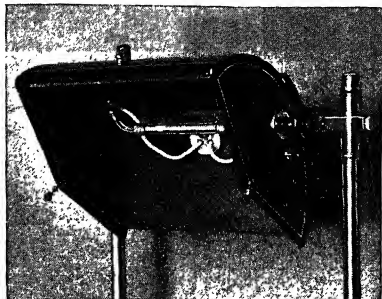


FIG. 227.—The Hanovia Muir Analytic Lamp, with Wood's filter removed to show the arc tube. (Hanovia, Ltd.)

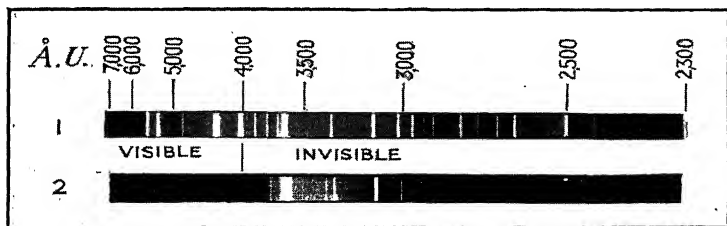


FIG. 228.—1, Spectrum of the quartz mercury arc (unfiltered).
2, Spectrum taken through the special analytic lamp filter. (Hanovia, Ltd.)

A sheet of ordinary window glass 1 mm. thick will prevent the passage of all ultra-violet rays below $3,000 \text{ \AA.U.}$, whilst a thicker glass will cut out many of the longer rays also.

In unfiltered ultra-violet light fluorescence cannot be readily observed, as the intense light from the lamp masks the relatively weak fluorescent light. In the Analytic Quartz lamp, however, the visible light is entirely absorbed by the

Wood's filter. This is 6 inches by 8 inches, made in four pieces to obviate cracking under the heat it develops in use. It transmits only rays between about 3,000 Å.U. and 4,000 Å.U.

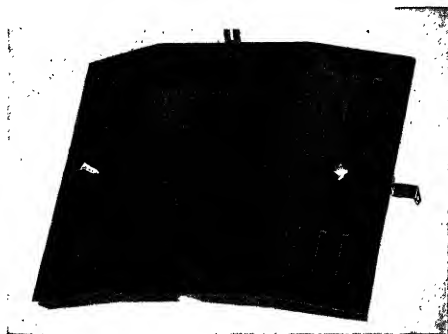


FIG. 229.—The cover plate detached from the Hanovia Muir Analytic Lamp, showing Wood's filter and ventilation louvers. (Hanovia, Ltd.)

(see Fig. 228, 2). The brightest band in this region is situated at about 3,660 Å.U. and is the most important one for exciting fluorescence in substances placed in the observation chamber.

The Examination of Pharmaceutical Products

(a) **Solids and Simple Solutions.**—Solids may be placed directly in the observation chamber, while liquids may be examined in non-

fluorescent dishes or test tubes. Many alkaloids in the solid state show distinct colours, *e.g.* aconitine (light blue), berberine (yellow), and emetine (orange). Those alkaloids which fluoresce in neutral solution usually show an increase in fluorescence on the addition of acid and a decrease on the addition of alkali. Pieces of cinchona bark when placed under the lamp show a number of luminous yellow patches and a few light blue ones. If the inner surface of the bark is touched with acid the spot immediately turns blue. Ipecacuanha root has a brightly luminous appearance wherever the wood is exposed, while the wood of hydrastis rhizome shines golden yellow. Areca nuts when cut show a light blue endosperm. Slices of calumba appear intensely yellow, with the cambium and phloem distinguished by their dark green colour.

(b) **Oils, Fats, and Waxes.**—Most oils, fats, and waxes show some fluorescence when examined in filtered ultra-violet light. Speaking generally, fixed oils and fats fluoresce least, waxes more strongly, and mineral oils (paraffins) most of all. For example, if 10 batches of suppositories are made with 10, 20, 30, 40, etc., up to 100 per cent. of paraffin wax and

the remainder cocoa butter, the series can be arranged in the correct order under the lamp, those containing the most wax having the strongest fluorescence (see Fig. 230). Similar results are obtained by mixing a fixed oil and liquid paraffin in different proportions. Butter shows a canary-yellow colour under the lamp, and margarine a bluish fluorescence which is sufficient to detect 25 per cent. of margarine when mixed with butter. The use of the lamp in the examination of olive oils is discussed on p. 544.

(c) Powders may be examined macroscopically as above or microscopically by means of a luminescence microscope.

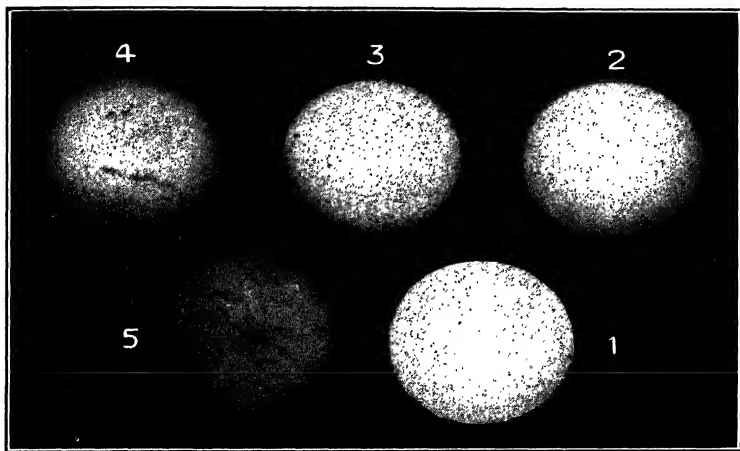


FIG. 230.—Paraffin wax and cocoa butter in filtered ultra-violet light. 1, Pure wax; 2, wax + 25 per cent. cocoa butter; 3, wax + 50 per cent. cocoa butter; 4, wax + 75 per cent. cocoa butter; 5, pure cocoa butter. (Lumino-gram (fluorescence photograph) by Lieut.-Col. Mansfield, London.)

In the latter case, if transmitted and not reflected light is to be used, it will be necessary to use quartz slides instead of the usual glass ones. For details of fluorescent microscopy Radley and Grant's *Fluorescence Analysis* and papers by Wasicky should be consulted. In all work on fluorescence one is faced with the difficulty of recording the results obtained in a form which allows of comparison with other material examined at a different date. The Guild colorimeter was used by Morgan and MacLellan to record the fluorescence of butter and

margarine samples in terms of three primary colours—red, blue, and green. This apparatus is, however, too expensive for general use.* Photographic records, although not entirely satisfactory, are useful and require less expensive apparatus. Lieut.-Col. Mansfield, of London, has evolved a method of making such photographs, to which he has given the name "Luminograms." Such luminograms are shown in Figs. 230 and 231. Among the uses of the lamp and the fluorescence microscope in connection with powdered drugs may be mentioned the detection of ergot in flour, of cocoa shells in powdered cocoa, and of rumex in powdered gentian. Different varieties of rhubarb may be distinguished from one another. Maheu describes *Rheum officinale*, *R. tanguticum*, and *R. Emodi* as having a brown fluorescence, and *Rheum compactum*, *R.*

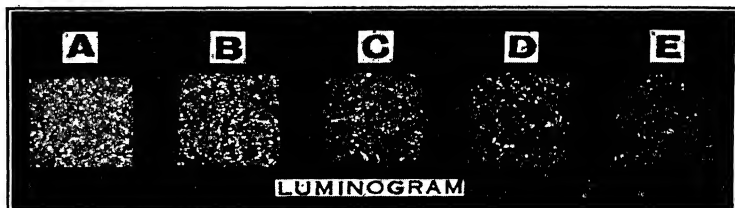


FIG. 231.—Powdered rhubarbs in filtered ultra-violet light. A, Pure Chinese rhapontic; B, Shensi + 50 per cent. Chinese rhapontic; C, Shensi + 20 per cent. Chinese rhapontic; D, Shensi + 10 per cent. Chinese rhapontic; E, pure Shensi. (Luminogram (fluorescence photograph) by Lieut.-Col. Mansfield, London.)

undulatum, *R. ribes*, and *R. rhaponticum* as showing a violet colour. The colour differences which exist in such cases, although quite obvious to the observer, are extremely difficult to put into words, and it also frequently happens that continued exposure to the ultra-violet light affects the colour and intensity of the fluorescence. The British Pharmacopœia now includes a fluorescence test for the detection of rhapontic rhubarb (see p. 321).

(d) Extracts such as chlorophyll, may be examined in quartz test tubes. In such cases photographs of the fluorescence spectrum will frequently show the nature of the substance under examination. Aqueous extracts of balsam of Peru

* For a description of the Guild colorimeter and its use in this connection, see Trease, *P.J.*, 1930, 264.

show a bright blue colour. The fluorescence of commercial orange-flower water decreases with age and the lamp may therefore be usefully employed for its examination.

For liquids containing more than one substance in solution the capillary analysis method has been successfully applied by Danckwortt, Pfau, and Jentschitsch. Non-fluorescent filter-paper is cut into strips 30 cm. long and 2.5 cm. wide. A 1 per cent. aqueous extract of the drug is made and divided into two portions. To one portion acetic acid is added and to the other solution of ammonia. The strips of filter-paper are suspended with their ends in these liquids for one hour and then examined, either when moist or after drying. Comparable results are only obtained if the conditions used in all tests are exactly alike. A few of the results obtained are tabulated below :—

Drug.	Alkaline Solution.	Acid Solution.
Catechu ..	Reddish-grey. Yellowish zone, shading to brownish-violet. Brown edge.	Whitish-yellow, blending to bluish. Edge whitish-violet.
Lavender flowers	Bright green, with a dark brown edge.	Dark violet, then a very dark and a light zone. Pale luminous edge.
Russian liquorice	Dull yellow-green and grey zones.	The same, but brighter.
Senna leaves ..	Reddish-grey. Dark and light grey zones. Luminous light yellow edge.	Yellow to bright grey. Narrow light violet and grey zones. Light yellow edge.

In conclusion, it may be mentioned that in all cases where a fluorescence is observable in daylight it is much more marked in ultra-violet light. When performing the well-known umbelliferone and quinine tests it should be noted that the fluorescence is much more readily seen near a window, where the light is relatively rich in short waves, than in a dull or artificially illuminated room. Drugs such as copaiba and Canada balsam, which only show slight fluorescence in daylight, show a strong fluorescence in ultra-violet light. In the case of copaiba, it may be noted that samples which appear absolutely non-fluorescent in daylight will show strong fluorescence under the lamp.

CHAPTER XXVI

EXERCISES ON THE EVALUATION OF DRUGS

By H. O. MEEK, Ph.C., and G. E. TREASE

THE evaluation of a drug includes its identification and the determination of its quality, purity and, if adulterated, the nature of the adulteration. At the present time the deliberate adulteration of drugs is much less common than was formerly the case but their *quality* often leaves much to be desired. Numerous examples of the methods used to evaluate drugs have been referred to throughout this book and the present chapter is intended as a summary and extension of the subject.

Samples.—Considerable care must be taken to ensure that a sample taken for examination truly represents the whole consignment of drug. The sampling of drugs by the Port of London Authority is described in Chapter II whilst the methods of sampling used in the United States are fully described in the U.S.P.

Preliminary Examination.—In the case of whole drugs the macroscopical and sensory characters are usually sufficient to enable the drug to be identified. The general appearance of the sample will often indicate whether it is likely to comply with such official standards as the percentage of seed in colocyath, percentage of ash in valerian, or percentage of matter insoluble in alcohol in asafetida. Drugs may, however, comply with the descriptions given in the Pharmacopœia and yet be unsatisfactory since it is often difficult to specifically describe deterioration of drugs due to faulty harvesting, shipment or storage or deterioration due to age. In such cases the trained worker will be able to infer much of the history of the sample from its appearance. The following examples will serve to indicate the type of evidence to look for.

If leaves and similar structures are baled before being properly dried much discoloured material may be found in the middle of the bale. Overdrying on the other hand makes leaves very brittle and causes them to break in transit. If

starch-containing drugs break with a horny fracture (it may usually be inferred that the temperature of drying has been too high and that the starch has been gelatinised). A pale colour in the case of chamomiles indicates that the drug has been collected in dry weather and carefully dried, whilst the colour of the fractured surface of gentian is a good indication as to whether it has been correctly fermented. Some drugs are particularly liable to deterioration if, during shipment or storage, they become damp, e.g. cascara. Under moist conditions moulds readily establish themselves on drugs having a high mucilage-content, e.g. psyllium, linseed, squill, and cydonia. Evidence of insect attack must also be looked for (see Chapter VII).

The price of certain drugs depends largely on such factors as size and colour which are not necessarily related to therapeutic value. This applies to such important drugs as senna leaflets, senna pods, chamomile flowers, ginger, nutmegs, and rhubarb.

Foreign Matter.—The difficulty of obtaining vegetable drugs in an entirely pure condition is fully recognised, and pharmacopœias contain statements as to the percentage of other parts of the plant or of other organic matter which may be permitted. Drugs containing appreciable quantities of potent foreign organic matter, animal excreta, insects, or mould should, however, be rejected even though the percentage of such substances be insufficient to cause the rejection of the drug on the percentage of foreign matter.

In the case of whole drugs a weighed quantity (25 to 500 G. according to the type of drug), of a carefully taken sample is spread in a thin layer on paper. The foreign matter is picked out, weighed and the percentage recorded. For foreign organic matter in powdered drugs, see Chapter XII and the B.P.C.

Exercise 1.—Using 25 G. of a sample of *whole* buchu ascertain if it complies with the requirement “contains not more than 5 per cent. of the stems and not more than 2 per cent. of other organic matter.”

Exercise 2.—Suitable exercises on the determination of foreign organic matter in *powdered* drugs would be the determination of stalk in senna (see Example 2, p. 157) or stem in *ipecacuanha*.*

Ash Values.—When vegetable drugs are incinerated they commonly leave an ash containing the elements mentioned on p. 55. In the case of many drugs, e.g. rhubarb, the

* For details see Lupton, *Y.B.Pharm.*, 1938, 2, 225.

percentage of *total ash* varies within fairly wide limits and is therefore of little value for purposes of evaluation. In other cases, e.g. peeled and unpeeled liquorice, the total ash figure is of importance and indicates to some extent the amount of care taken in the preparation of the drug. If the total ash be treated with dilute hydrochloric acid the percentage of *acid-insoluble ash* may be determined. This usually consists mainly of silica and a high acid-insoluble ash in drugs such as senna, cloves, liquorice and tragacanth indicates contamination, with earthy material. If a comparatively small percentage of acid-insoluble ash (usually due to stones) is present in senna leaf any Confection of Senna prepared from it would be unpleasantly gritty. In the case of ginger a minimum percentage of *water-soluble ash* is demanded this being designed to detect the presence of exhausted ginger.

In the determination of ash values the carbon must be removed at as low a temperature as possible, since alkali chlorides, which may be volatile at high temperatures, would otherwise be lost. If carbon is still present after heating at a moderate temperature the water-soluble ash may be separated and the residue again ignited as described in the B.P. and U.S.P. The total ash usually consists mainly of carbonates, phosphates, silicates, and silica. If such an ash, sometimes termed a "carbonate ash," be overheated the carbonates will be partly converted into oxides. It has therefore been suggested* that the ash should be "recarbonated" by treatment with solution of ammonium carbonate, evaporated and dried in a water-oven. Carbon-free ashes are also readily obtained by the use of fuming nitric acid,† but "nitrated ash" figures, are lower than "carbonate ash" ones.‡ This method finds favour in some Continental countries.

Exercise 3.—Weigh out about 2 to 3 G. of powdered senna into a tared silica crucible and ash as described in the B.P. or U.S.P. Calculate the percentage of ash in the air-dry drug. The British Pharmacopœia bases its ash values on the drug dried at 100°, but the U.S.P. and many workers in this country calculate the result on the air-dried drug.§

* Liverseege, *P.J.*, 1922, **54**, 426.

† Winkler, *Pharm. Zentralh.*, 1932, **73**, 593, 612, 705.

‡ Müller, *Pharm. Zentralh.*, 1936, **77**, 205, 221.

§ Some vegetable drugs are extremely difficult to dry to constant weight and we have personally found that some gums continue to lose weight for weeks when heated at 100°.

Exercise 4.—Boil the ash obtained in Exercise 3 with 25 mls of dilute hydrochloric acid. Collect the acid-insoluble matter on a filter having a known ash-content, wash and ignite to constant weight. Calculate the percentage of acid-insoluble ash in the air-dry drug.

Exercise 5.—Using the B.P. method determine the total ash and water-soluble ash (calculated on the drug dried at 100°) of the sample labelled "Zingiber." Different students may be supplied with the official Jamaica drug, exhausted ginger and Nigerian ginger (cf. p. 270 and 271).

Moisture Content of Drugs.—For drugs containing no constituents volatile at 100° the method used in Exercise 6 is suitable, but for drugs containing volatile constituents, e.g. volatile oil, the procedure described in Exercises 7 should be used.

Exercise 6.—Weigh about 10 G. of drug (which if whole should first be coarsely ground) in a tared dish. Dry at 100° for 5 hours, weigh, and repeat the drying and weighing at hourly intervals until the loss is not more than 0.25 per cent. in one hour's drying. Suitable drugs for this exercise are Digitalis and Aloe or fibres such as Corchorus, B.P.C.

Exercise 7.—The moisture content of drugs may also be determined by distilling a weighed quantity of drug with toluene in the apparatus shown in Fig. 232. Details of the method are given in the U.S.P. A paper by Tate and Warren should also be consulted.* The amount of drug taken should be such that about 2 to 4 cc. of water are collected in the graduated receiver C. Measurement of the volume of water evolved is facilitated if a trace of methylene blue is placed in the receiver.

Extractive Values.—The determination of water-soluble or alcohol-soluble extractive is commonly used as a means of evaluating drugs the constituents of which are not readily estimated by other means. Such determinations are useful in the cases of the following drugs :—

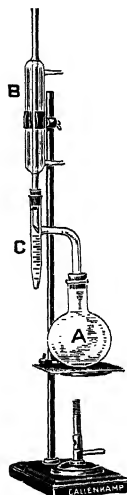


Fig. 232.—Toluene Moisture Apparatus (A. Gallenkamp & Co., Ltd.)

Drug.	Method of Evaluation.
Aloes, cascara, gentian and liquorice.	Percentage of water-soluble extractive.
Rhubarb	Percentage of alcohol (45 per cent.)-extractive.

* Tate and Warren, *Analyst*, 1936, 61, 367.

PHARMACOGNOSY

Drug.

Method of Evaluation.

Ginger, ipomoea, and jalap	Percentage of alcohol (90 per cent.)-extractive.
Asafetida, catechu, and myrrh.	Limits of alcohol-insoluble matter.
Colocynth	Limit of light petroleum extractive.
Crushed linseed .. .	Percentage of ether-soluble extractive.

In certain cases extraction of the drug is by maceration, in others by a continuous extraction process.

Exercise 8.—Determine the water-soluble extractive of a sample of liquorice by maceration with chloroform water as described in the B.P.

Exercise 9.—Determine the alcohol (45 per cent.)-extractive of a sample of rhubarb or the alcohol (90 per cent.)-extractive of a sample of ginger by maceration as described in the B.P. Note.—American students should use the continuous extraction process of the U.S.P.

Exercise 10.—Determine the percentage of resin soluble in alcohol (90 per cent.) in a sample of jalap by the continuous extraction process described in the B.P.

Determination of Volatile Oil.—Minimum standards for the percentage of volatile oil in drugs are prescribed by the U.S.P. XI. The U.S.P. method is to dry the drug over sulphuric acid extract with ether, remove the solvent by spontaneous evaporation, weigh the extractive, drive off the volatile oil by heating at 110° and again weigh. This process is a very lengthy one and in Britain a distillation method using an apparatus such as that recently described by Meek and Salvin (1) (Fig. 233) is often used. The drug is placed in the distillation flask with water or a mixture of water and glycerine; the oil and water are condensed and the volatile oil collects in a graduated receiver in which its volume is measured. For oils of high specific gravity separation from the water is assisted by placing a known volume of xylol in the receiver. The time taken to complete the distillation of the oil naturally varies with the nature of the drug and its state of comminution but about four hours is usually sufficient. The following volatile oil figures of a few important drugs are taken from Meek and Salvins' paper which should be consulted for further details.

* Meek and Salvin, *Y.B.Pharm.*, 1937, 471-485. See also Short, *Y.B.Pharm.*, 1931, 444, and Cocking and Middleton, *Y.B.Pharm.*, 1932, 521, and *Y.B.Pharm.*, 1935, 435.

Exercise 16.—Nitrogen estimation of saffron by Kjeldahl method (see p. 561).

Exercise 17.—Crude fibre in clove by U.S.P. method.

Exercise 18.—Acid value of colophony resin by B.P. method.

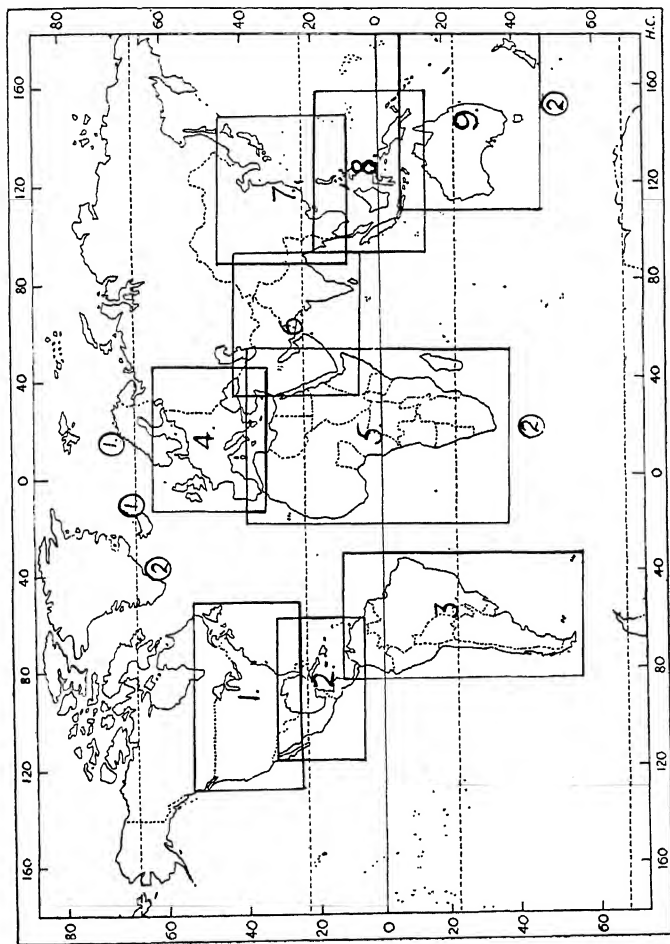
Exercise 19.—Determination of oil in linseed meal.

Exercise 20.—Examination of genuine and adulterated powdered rhubarbs in ultra violet light.

Exercise 21.—Pungency of capsicum (see Berry & Samways, *Y.B.Pharm.*, 1937, 387)

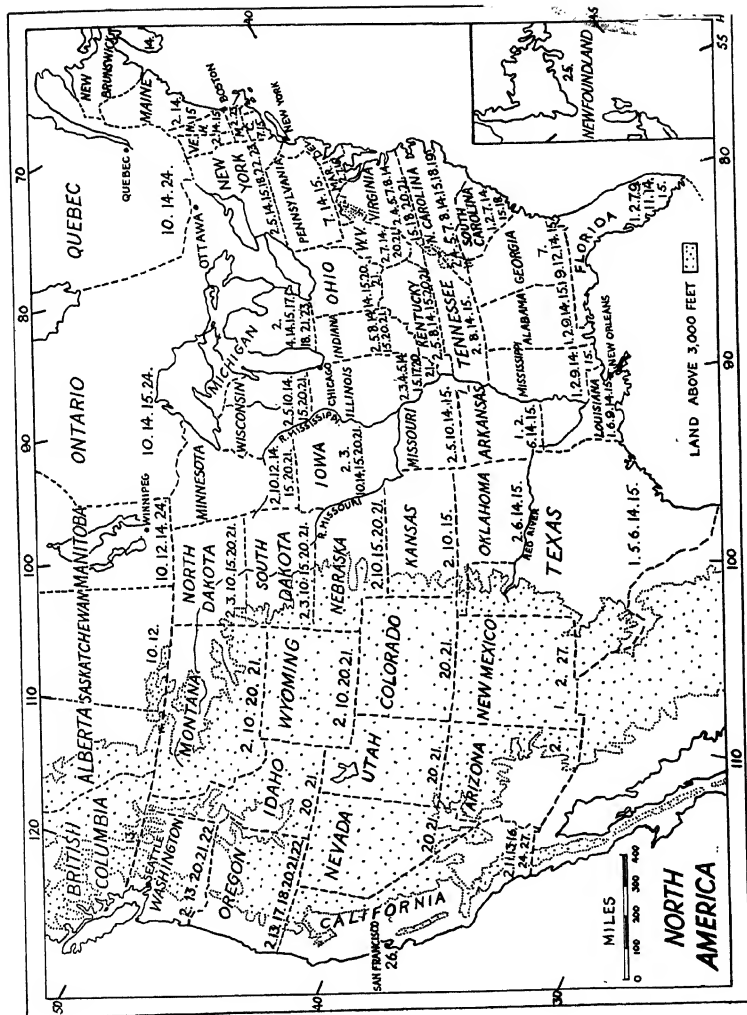
THE WORLD

This map shows the areas covered by Maps 1 to 9.
It also marks the regions in which cod liver oil, marked ① on the map, and spermaceti, marked ② on the map, are collected.



MAP I. NORTH AMERICA

<i>Number on Map</i>	<i>Drug</i>	<i>References</i>
1.	Resin	p. 205 and Map 4
2.	Pine Tar	p. 208 and Map 4.
3.	Maize Starch	p. 90 and Maps 2, 3, 4, and 5.
4.	American Veratrum	p. 232.
5.	Cannabis	p. 300 and Maps 5 and 6.
6.	Serpentary (Texan)	p. 308.
7.	Serpentary (Virginian)	p. 309.
8.	Podophyllum (American)	p. 362.
9.	Cotton	p. 129 and Maps 3, 5, and 6.
10.	Linseed	p. 412 and Maps 3 and 6.
11.	Lemon Peel and Oil	p. 431 and Maps 2, 4, and 9.
12.	Senega	p. 443.
13.	Cascara	p. 447 and Map 5.
14.	Witch Hazel	p. 453.
15.	Wild Cherry	p. 459.
16.	Olive Oil	p. 543 and Maps 4, 5, and 9.
17.	Peppermint	p. 570 and Map 4.
18.	Spearmint	p. 571 and Map 4.
19.	Stramonium	p. 572 and Map 4.
20.	Henbane	p. 577 and Map 4.
21.	Belladonna	p. 581 and Map 4.
22.	Digitalis	p. 592 and Map 4.
23.	Lobelia	p. 626.
24.	Honey and Beeswax	p. 648 and Maps 2, 3, 4, 5, 6, and 9.
25.	Cod Liver Oil	p. 655 and Map 4.
26.	Spermaceti	p. 659 and Maps 7 and 9.
27.	Eriodictyon	p. 566.



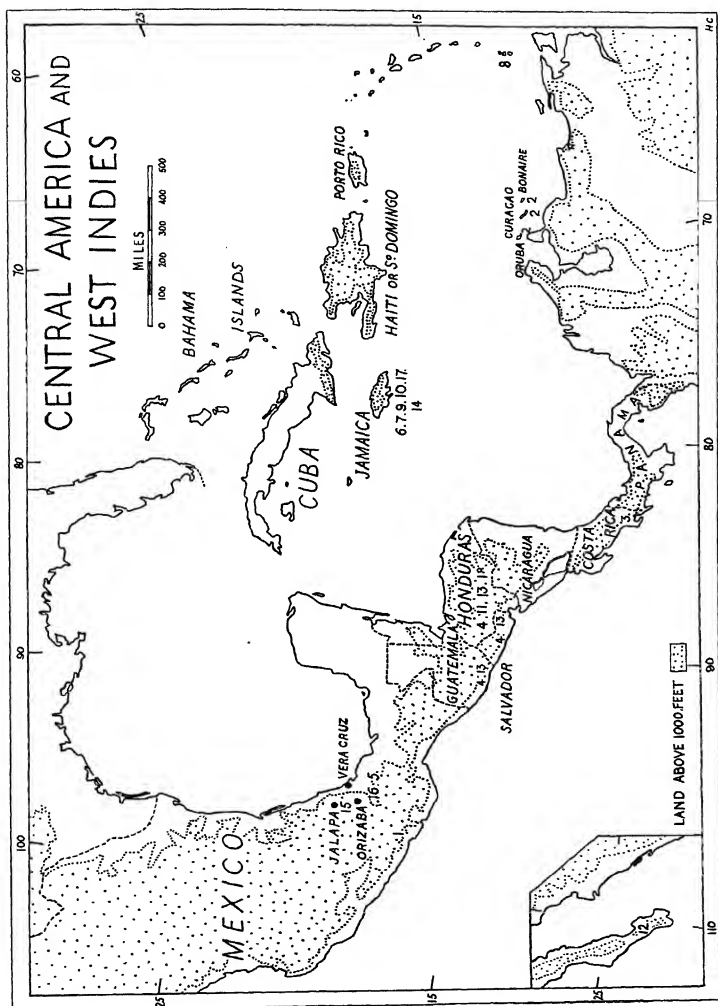
MAP 2. CENTRAL AMERICA AND WEST INDIES

Number
on

Map

References

- | | | |
|-----|---------------------------|---------------------------------------|
| 1. | Maize Starch | p. 90 and Maps 1, 3, 4, and 5. |
| 2. | Aloes | p. 238 and Map 5. |
| 3. | Sarsaparilla (Costa Rica) | p. 254. |
| 4. | „ (Honduras) | p. 255. |
| 5. | „ (Vera Cruz) | p. 256. |
| 6. | „ (Native Jamaica) | p. 256. |
| 7. | Ginger | p. 265. |
| 8. | Nutmeg | p. 330 and Maps 6 and 8. |
| 9. | Lemon Peel and Oil | p. 431 and Maps 1, 4, and 9. |
| 10. | Quassia | p. 438. |
| 11. | Storax (American) | p. 456. |
| 12. | Quillaia | p. 463. |
| 13. | Balsam of Peru | p. 482. |
| 14. | Tamarinds | p. 502. |
| 15. | Jalap | p. 560 and Map 7. |
| 16. | Ipomœa | p. 563 |
| 17. | Honey and Beeswax | p. 648 and Maps 1, 3, 4, 5, 6, and 9. |
| 18. | Cochineal | p. 650 and Map 5. |



MAP 3. SOUTH AMERICA

*Number
on
Map*

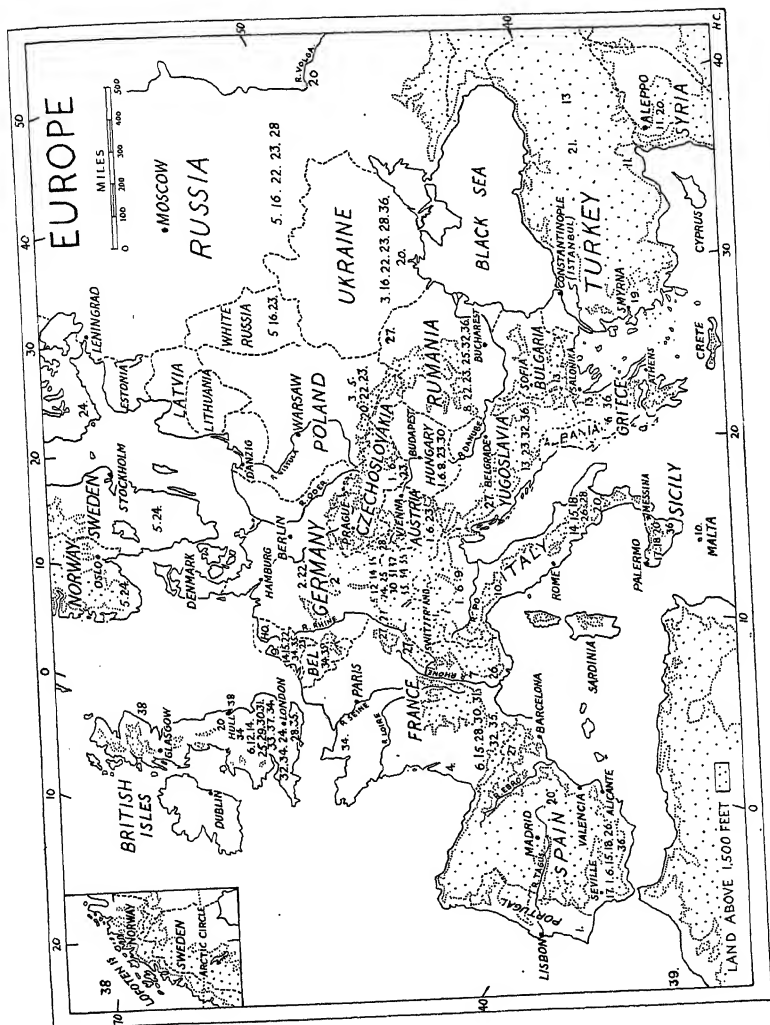
References

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|-----|-------------------------|--|
| 1. | Maize Starch | p. 90 and Maps 1, 2, 4, and 5. |
| 2. | Black Mustard | p. 386 and Map 4. |
| 3. | Cotton | p. 129 and Maps 1, 5, and 6. |
| 4. | Linseed | p. 412 and Maps 1, 4, and 6. |
| 5. | Coca | p. 414 and Map 8. |
| 6. | Quillaia | p. 463 and Map 2. |
| 7. | Chrysarobin | p. 479. |
| 8. | Balsam of Tolu | p. 480. |
| 9. | Krameria | p. 505. |
| 10. | Copaiba | p. 506. |
| 11. | Cinchona | p. 600 and Maps 6 and 8 |
| 12. | Ipecacuanha (Rio) | p. 609 and Map 8. |
| 13. | Ipecacuanha (Cartagena) | p. 613. |
| 14. | Honey and Beeswax | p. 648 and Maps 1, 2, 4, 5, 6,
and 9. |



MAP 4. EUROPE

<i>Number on Map</i>	<i>Drug</i>	<i>References</i>
1.	Ergot	p. 187.
2.	Male Fern	p. 195.
3.	Lycopodium	p. 199.
4.	Resin	205 and Map 1.
5.	Pine Tar	208 and Map 1.
6.	Savin	216.
7.	Juniper Tar Oil	218.
	Maize Starch	p. 90 and Maps 1, 3, and 5.
	Colchicum Corm and Seeds	pp. 236 and 237.
10.	Squill	p. 249.
11.	Galls	p. 292.
12.	Aconite	p. 348.
13.	Opium	p. 373 and Map 6.
14.	Black Mustard	p. 386.
15.	Althæa	p. 399.
16.	Linseed	p. 412 and Maps 1, 3, and 6.
17.	Orange Peel	p. 428.
18.	Lemon Peel and Oil	p. 431 and Maps 1, 2, and 9.
19.	Storax (Levant)	p. 455.
20.	Liquorice	p. 470 and Map 6.
21.	Tragacanth (Anatolian)	p. 484 and Map 6.
22.	Fennel	p. 520.
23.	Coriander	p. 524.
24.	Caraway	p. 526.
25.	Dill	p. 528.
26.	Olive Oil	p. 543 and Maps 1, 5, and 9.
27.	Gentian	p. 551.
28.	Peppermint	p. 570 and Map 1.
29.	Spearmint	p. 571 and Map 1.
30.	Stramonium	p. 572 and Map 1.
31.	Henbane	p. 577 and Map 1.
32.	Belladonna	p. 581 and Map 1.
33.	Digitalis	p. 592 and Map 1.
34.	Valerian	p. 622.
35.	Chamomiles	p. 630.
36.	Cantharides	p. 645.
37.	Honey and Beeswax	p. 648 and Maps 1, 2, 3, 5, and 9.
38.	Cod Liver Oil	p. 655 and Maps 0 and 1.
39.	Spermaceti	p. 659 and Maps 0, 1, 7, and 9.



MAP 5. AFRICA

Number
on

Maps

References

Map

- | | | |
|-----|-------------------|--|
| 1. | Maize Starch | p. 90 and Maps 1, 2, 3, and 4 |
| 2. | Aloes | p. 238 and Map 2. |
| 3. | Cannabis | p. 300 and Maps 1 and 6. |
| 4. | Calumba | p. 367. |
| 5. | Colocynth | p. 392. |
| 6. | Cotton | p. 129 and Maps 1, 3, and 6. |
| 7. | Buchu | p. 421. |
| 8. | Myrrh | p. 440. |
| 9. | Cascara | p. 447 and Map 1. |
| 10. | Acacia | p. 491. |
| 11. | Senna | p. 495 and Map 6. |
| 12. | Cloves | p. 511 and Map 8. |
| 13. | Coriander | p. 524 and Maps 4 and 6. |
| 14. | Caraway | p. 526 and Map 4. |
| 15. | Olive Oil | p. 543 and Maps 1, 4, and 9. |
| 16. | Nux Vomica | p. 546 and Map 6. |
| 17. | Strophanthus | p. 555. |
| 18. | Chillies | p. 587. |
| 19. | Honey and Beeswax | p. 648 and Maps 1, 2, 3, 4, 6,
and 9. |
| 20. | Cochineal | p. 650 and Map 2. |

MAP 6. S.W. ASIA AND INDIA

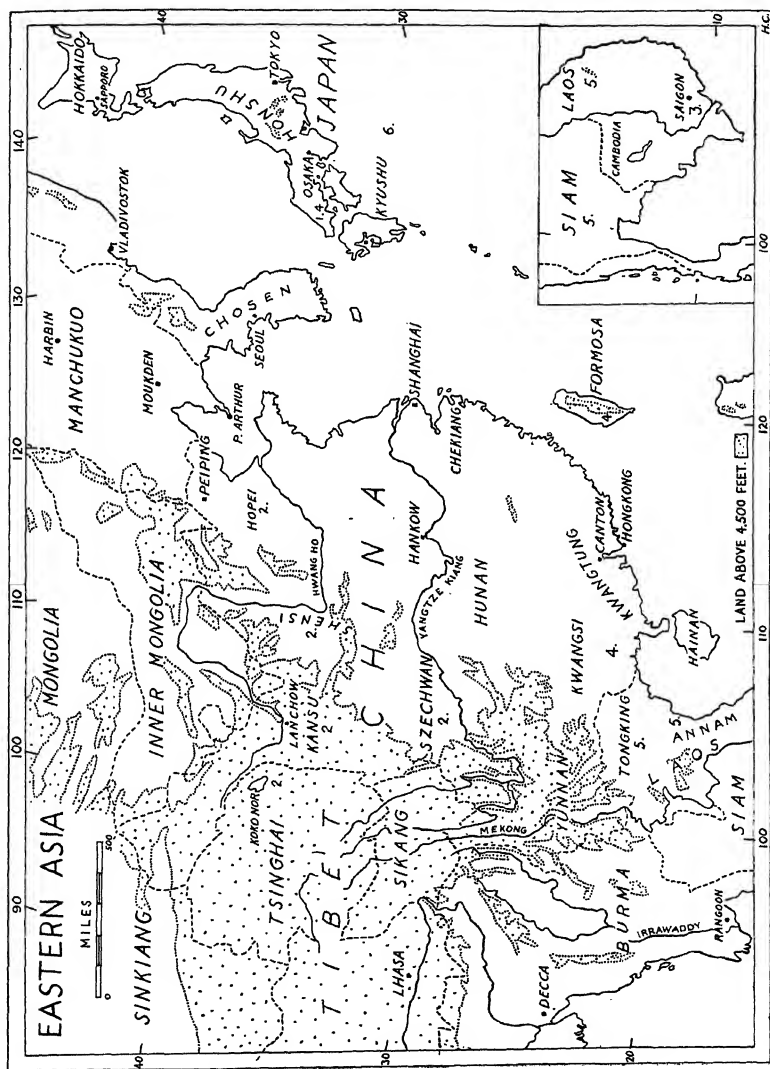
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References

1.	Aloes	238 and Maps 2 and 5.
2.	Cardamom	273.
3.	Cannabis	300 and Maps 1 and 5.
4.	Nutmeg	330 and Maps 2 and 8.
5.	Cinnamon (Ceylon)	336.
6.	Podophyllum (Indian)	365.
7.	Opium	373 and Map 4.
8.	Cotton	129 and Maps 1, 3, and 5.
9.	Linseed	412 and Maps 1, 3, and 4.
10.	Liquorice	470 and Map 4.
11.	Tragacanth (Persian)	484 and Map 4.
12.	Senna	495 and Map 5.
13.	Coriander	524 and Maps 4 and 5.
14.	Asafoetida	531.
15.	Nux Vomica	546 and Map 5.
16.	Jalap	560 and Map 2.
17.	Cinchona	600 and Maps 3 and 8.
18.	Honey and Beeswax	648 and Maps 1, 2, 3, 4, and 9.

MAP 7. EASTERN ASIA

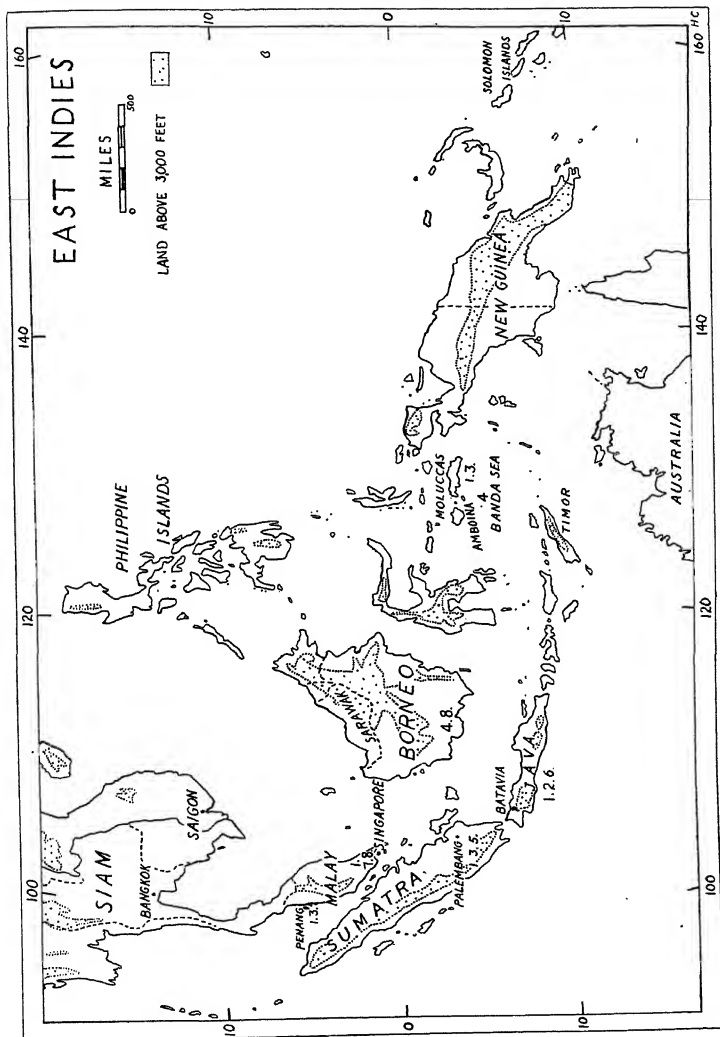
<i>Number on Map</i>	<i>Drug</i>	<i>References</i>
1.	Agar	p. 182.
2.	Rhubarb	p. 310.
3.	Cinnamon (Saigon)	p. 344.
4.	Camphor	p. 346.
5.	Benzoin (Siamese)	p. 54
6.	Spermaceti	p. 659 and Maps 0, 1, 4, and 9.



MAP 8. EAST INDIES

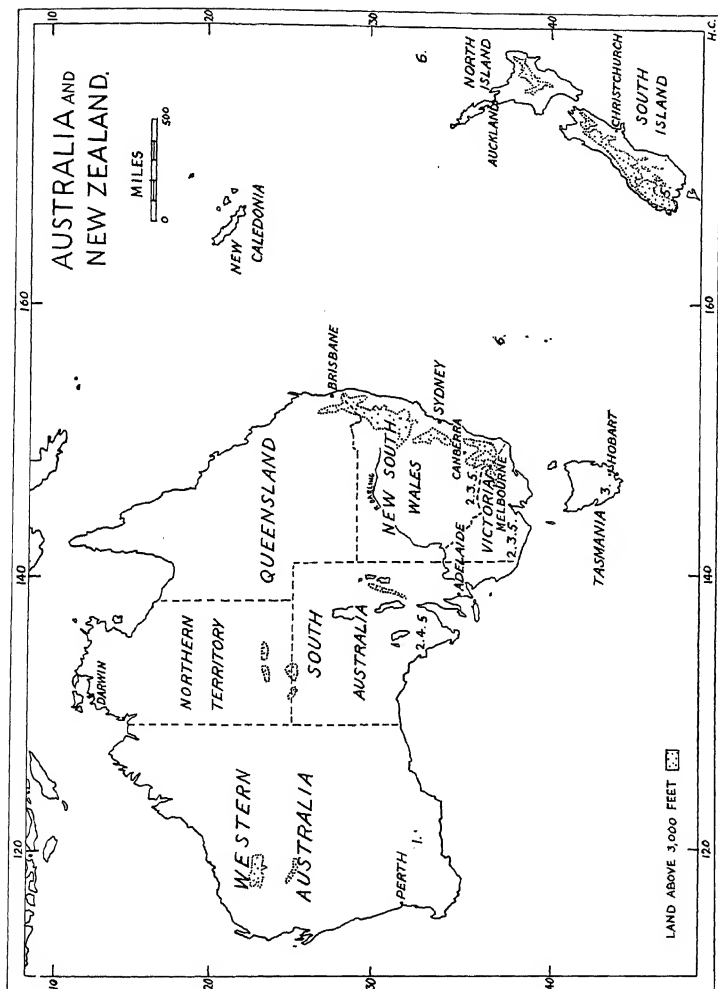
*Number
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Map**References*

- | | | |
|----|----------------------|--------------------------|
| 1. | Nutmeg | p. 330 and Maps 2 and 6. |
| 2. | Coca | p. 414 and Map 3. |
| 3. | Cloves | p. 511 and Map 5. |
| 4. | Oil of Cajuput | p. 518. |
| 5. | Benzoin (Sumatra) | p. 539. |
| 6. | Cinchona | p. 600 and Maps 3 and 6. |
| 7. | Ipecacuanha (Johore) | p. 612 and Map 3. |
| 8. | Gambir | p. 615. |



MAP 9. AUSTRALIA AND NEW ZEALAND

<i>Number on Map</i>	<i>Drug</i>	<i>References</i>
1.	Australian Sandalwood Oil	p. 397.
2.	Lemon Peel and Oil	p. 431 and Maps 1, 2, and 4.
3.	Eucalyptus Oil	p. 516.
4.	Olive Oil	p. 543 and Maps 1, 4, and 5.
5.	Honey and Beeswax	p. 648 and Maps 1, 2, 3, 4, and 6.
	Spermaceti	p. 659 and Maps 0, 1, and 7.



GLOSSARY OF LATIN WORDS USED IN NAMING SPECIES

- Acuminatus**, a, um, pointed, sharp, e.g. *Fusanus acuminatus*.
Acutus, a, um, pointed ; **folium**, leaf, e.g. *Cassia acutifolia*.
Alatus, a, um, winged, e.g. *Rhus semialata*.
Albus, a, um, white, e.g. *Brassica alba*.
Alpinus, a, um, alpine, e.g. *Rumex alpinus*.
Amarus, a, um, bitter, e.g. *Quassia amara*.
Ambrosia, æ, immortality, the food of the gods, e.g. *Chenopodium ambrosioides*.
Ammoniacum, i, a gum-resin prepared near the temple of Jupiter Ammon, e.g. *Dorema ammoniacum*.
Angustus, a, um, narrow ; **folium**, a leaf, e.g. *Cassia angustifolia*.
Annuus, a, um, of a year's duration, e.g. *Capsicum annuum*.
Anthelminticus, a, um, against worms, e.g. *Brayera anthelmintica*.
Arboreus, a, um, like a tree, e.g. *Gossypium arboreum*.
Argenteus, a, um, silvery, e.g. *Krameria argentea*.
Arista, æ, the beard of an ear of corn, e.g. *Berberis aristata*.
Aromaticus, a, um, aromatic, e.g. *Eugenia aromatica*.
Arundinaceus, a, um, like a reed, e.g. *Maranta arundinacea*.
Autumnalis, e, of the autumn, e.g. *Colchicum autumnale*.

Balsameus, a, um, balsamic, e.g. *Abies balsamea*.
Betula, æ, the birch, e.g. *Barosma betulina*.
Brevis, e, short, little ; **folium**, leaf, e.g. *Artemisia brevifolia*.

Calamus, i, a reed, a cane, e.g. *Acorus Calamus*.
Campester, **campestris**, of the fields, e.g. *Brassica campestris*.
Campus, i, a plain, a field, e.g. *Grindelia camporum*.
Candidus, a, um, white, clear, shining, e.g. *Marrubium candidissimum*.
Caninus, a, um, canine, e.g. *Rosa canina*.
Capillaceus, a, um, hair-like, e.g. *Fœniculum capillaceum*.
Catharticus, a, um, cathartic, e.g. *Rhamnus cathartica*.*

* Students are reminded that the names of trees in Latin are feminine and that botanical names such as *Ulmus fulva* and *Prunus serotina* are no exception to the rule that the adjective agrees in gender with the noun.

Centifolia rosa, the hundred-leaved rose (Pliny), *Rosa centifolia*.
 Ceriferus, a, um, wax bearing, e.g. *Copernica cerifera*.
 Cichorium, ii, chicory, endive, e.g. *Myiobris cichorii*.
 Clava, æ, a knotty branch, a club, e.g. *Lycopodium clavatum*.
 Coccineus, a, um, scarlet coloured, e.g. *Chrysanthemum coccineum*.
 Communis, e, common, e.g. *Juniperus communis*.
 Coriarius, a, um, of or pertaining to leather, e.g. *Rhus coriaria*.
 Crispus, a, um, crisped, curled, indented, e.g. *Chondrus crispus*.
 Crocatus, a, um, saffron-like, e.g. *Enanthe crocata*.
 Cuneus, i, a wedge, e.g. *Grindelia cuneifolia*.
 Cyllene, a mountain of Arcadia, e.g. *Acacia cylleneus*.

Dealbatus, a, um, whitewashed, plastered, e.g. *Acacia dealbata*.
 Diffusus, a, um, spread, poured out, e.g. *Turnera diffusa*.
 Discolor, discoloris, of another colour, e.g. *Salix discolor*.
 Domesticus, a, um, belonging to the house, e.g. *Prunus domestica*.

Echinatus, a, um, set with prickles, e.g. *Prunus echinata*.
 Edulis, e, eatable, e.g. *Canna edulis*.
 Emeticus, a, um, emetic, e.g. *Psychotria emetica*.
 Equisetum, i, horsetail, e.g. *Ephedra equisetina*.
 Erinaceus, i, a hedgehog, e.g. *Pterocarpus erinaceus*.
 Europæus, a, um, of Europe, e.g. *Olea europæa*.
 Excelsus, a, um, lofty, high, e.g. *Picea excelsa*.

Fastuosus, a, um, full of pride, haughty, e.g. *Datura fastuosa*.
 Ferox, ocis, wild, savage, e.g. *Aloe ferox*.
 Filix, icis, a fern; mas, maris, male, e.g. *Dryopteris Filix-mas*.
 Fistula, æ, a pipe, a reed, e.g. *Cassia fistula*.
 Fœtidus, a, um (fetidus, a, um), fetid, e.g. *Ferula fœtida*.
 Fragilis, e, fragile, easily broken, e.g. *Salix fragilis*.
 Fragrans, tis, fragrant, e.g. *Myristica fragrans*.
 Frondosus, a, um, full of leaves, leafy, e.g. *Butea frondosa*.
 Fulvus, a, um, yellow, tawny, e.g. *Ulmus fulva*.

Galbanus, yellow; fluo, to flow, e.g. *Ferula galbaniflua*.
 Glabrus, a, um, bare, free from hairs, e.g. *Glycyrrhiza glabra*.
 Glanduliferus, a, um, gland-bearing, e.g. *Glycyrrhiza glandulifera*.
 Glaucus, a, um, bright, gleaming, greyish (Glaucus, i, a bluish-coloured fish mentioned by Pliny), e.g. *Simaruba glauca*.
 Globosus, a, um, round, spherical, e.g. *Mimusops globosa*.
 Globulus, i, a little ball, e.g. *Eucalyptus globulus*.
 Glutinosus, a, um, full of glue, viscous, e.g. *Alnus glutinosa*.
 Gratus, a, um, that which produces favour, agreeable, e.g. *Strophanthus gratus*.
 Graveolens, tis, smelling strongly, stinking, e.g. *Peucedanum graveolens*.

Grossus, a, um, thick (Grossus, i, an unripe fig), e.g. *Capsicum grossum*.

Gummifer, era, erum, gum-bearing, e.g. *Astragalus gummifer*.

Herbaceus, a, um, grassy, herbaceous, e.g. *Gossypium herbaceum*.

Hirtus, a, um (also hirsutus, a, um), rough, shaggy, e.g. *Euphorbia hirta*.

Hispidus, a, um, rough, shaggy, hairy, e.g. *Strophanthus hispidus*.

Holosericus, a, um, all of silk, e.g. *Cassia holoserica*.

Horridus, a, um, standing on end, rough, prickly, e.g. *Acacia horrida*.

Hypogæus, a, um, underground, e.g. *Arachis hypogæa*.

Indicus, a, um, of India, e.g. *Sesamum indicum*.

Infectorius, a, um, that serves for dyeing, e.g. *Quercus infectoria*.

Inflatus, a, um, swollen, inflated, e.g. *Lobelia inflata*.

Innoxius, a, um, harmless, innocuous, e.g. *Datura innoxia*.

Inodorus, a, um, without smell, e.g. *Matricaria inodora*.

Lanatus, a, um, woolly, e.g. *Digitalis lanata*.

Latifolius, a, um, broad-leaved, e.g. *Anogeissus latifolia*.

Lentiscus, i, the mastich-tree, e.g. *Pistacia lentiscus*.

Luteus, a, um, yellow, orange, e.g. *Gentiana lutea*. (N.B.—Luteus, a, um, of mud or clay.)

Maculatus, a, um, spotted, e.g. *Conium maculatum*.

Marginatus, a, um, furnished with a border, e.g. *Eucalyptus marginata*.

Maritimus, a, um, maritime, e.g. *Artemisia maritima*.

Maximus, a, um, greatest, e.g. *Cucurbita maxima*.

Medicus, a, um, healing, curing, e.g. *Smilax medica*.

Mellificus, a, um, honey-making, e.g. *Apis mellifica*.

Microphyllus, a, um, small-leaved, e.g. *Pilocarpus microphyllus*.

Minimus, a, um, smallest, e.g. *Capsicum minimum*.

Minusculus, a, um, somewhat little, e.g. *Elettaria Cardamomum*, var. *minuscula*.

Modestus, a, um, moderate, e.g. *Acacia modesta*.

Montanus, a, um, of or from a mountain, e.g. *Arnica montana*.

Muricatus, a, um, shaped like a purple fish, pointed, e.g. *Ipomœa muricata*.

Muticus, a, um, curtailed, docked, e.g. *Hyoscyamus muticus*.

Niger, gra, grum, black, e.g. *Hyoscyamus niger*.

Nitidus, a, um, shining, bright, e.g. *Gelsemium nitidum*.

Nobilis, e, known, famed, e.g. *Laurus nobilis*.

Nodosus, a, um, knotty, e.g. *Fucus nodosus*.

- Occidentalis, e, western, westerly, e.g. *Anacardium occidentale*.
 Odoratus, a, um, sweet smelling, e.g. *Dipteryx odorata*.
 Officina, æ, a workshop or shop, e.g. *Alpinia officinarum*.
 Officinalis, e, of a workshop or shop, officinal, e.g. *Calendula officinalis*.
 Oppositus, a, um, set against, set opposite, e.g. *Dipteryx oppositifolia*.
 Orientalis, e, eastern, oriental, e.g. *Liquidambar orientalis*.
 Ornatus, a, um, equipped, splendidly furnished, e.g. *Smilax ornata*.
 Ornus, i, the wild mountain ash, e.g. *Fraxinus ornus*.
 Ovatus, a, um, egg-shaped, ovate, e.g. *Plantago ovata*.
 Oxycedrus, i, a species of cedar with pointed leaves, e.g. *Juniperus Oxycedrus*.
 Palmatus, a, um, like the palm of the hand, e.g. *Jateorhiza palmata*.
 Paluster, tris, tre, marshy, swampy, e.g. *Pinus palustris*.
 Panicula, æ, a tuft, a panicle, e.g. *Anamirta paniculata*.
 Pallidus, a, um, pale, pallid, e.g. *Iris pallida*.
 Peltatus, a, um, armed with a pelta or small shield, e.g. *Podophyllum peltatum*.
 Peregrinus, a, um, that comes from foreign parts, exotic, e.g. *Marrubium peregrinum*.
 Potator, oris, a drinker, e.g. *Strychnos potatorum*.
 Procumbo, cubui, cubitum, ere, to fall forward, e.g. *Gaultheria procumbens*.
 Propinquus, a, um, near, neighbouring, e.g. *Dæmonorops propinquus*.
 Precator, oris, one that prays, e.g. *Abrus precatorius*.
 Prurio, ire, to itch, e.g. *Mucuna pruriens*.
 Psyllium, ii, a plant fleabane or fleawort mentioned by Pliny, e.g. *Plantago psyllium*.
 Pulchellus, a, um, beautiful, little, e.g. *Barosma pulchella*.
 Punctum, i, prick of a needle, point, dot, e.g. *Monarda punctata*.
 Purpureus, a, um, purple, e.g. *Digitalis purpurea*.
 Racemosus, a, um, clustering, racemose, e.g. *Cimicifuga racemosa*.
 Robustus, a, um, of oak or hard wood, hardy, strong, e.g. *Embelia robusta*.
 Religiosus, a, um, reverencing or fearing the gods, e.g. *Ficus religiosa*.
 Repens, tis, creeping, crawling, e.g. *Agropyron repens*.
 Resina, æ, resin; fero, tuli, latum, ferre, to bear, e.g. *Euphorbia resinifera*.
 Reticulatus, a, um, net-like, reticulated, e.g. *Aristolochia reticulata*.
 Rostratus, a, um, having a beak or hook, e.g. *Eucalyptus rostrata*.
 Ruber, bra, brum, red, e.g. *Dæmonorops ruber*.
 Rubricaulis, is, red stem, e.g. *Ferula rubricaulis*.

Sanctus, a, um, sacred, e.g. *Guaiacum sanctum*.

Sarmentosus, a, um, full of twigs or little branches, e.g. *Strophanthus sarmentosus*.

Sativus, a, um, cultivated, e.g. *Crocus sativus*.

Sempervirens, tis, always green, e.g. *Buxus sempervirens*.

Serotinus, a, um, late, that happens or does anything late, e.g. *Prunus serotina*.

Serpentaria, æ, snakeweed, e.g. *Aristolochia Serpentaria*.

Serratus, a, um, jagged like a saw, serrate, e.g. *Fucus serratus*.

Serrula, æ, a small saw, e.g. *Barosma serrulatum*.

Simulans, antis, imitating, e.g. *Ipomœa simulans*.

Somnifer, era, erum, sleep-bearing, soporific, deadly, e.g. *Papaver somniferum*.

Speciosus, a, um, good-looking, beautiful, e.g. *Hancornia speciosa*.

Spica, æ, point, ear, spike, e.g. *Lavandula spica*.

Spinosus, a, um, full of thorns or prickles, e.g. *Eucheuma spinosum*.

Spinulosus, a, um, full of little thorns or prickles, e.g. *Dryopteris spinulosa*.

Squarrosus, a, um, scurfy, scabby, e.g. *Grindelia squarrosa*.

Suaveolens, entis, sweet-smelling, fragrant, e.g. *Ferula suaveolens*.

Succedaneus, a, um, that replaces, that substitutes, e.g. *Rhus succedanea*.

Succulentus, a, um, full of juice, succulent, e.g. *Barosma succu-*

Sylvestris (silvestris), e, of or belonging to a wood or forest, e.g. *Pinus sylvestris*.

Tæda, æ, a resinous species of pine, e.g. *Pinus Tæda*.

Tenuis, e, thin, fine, close, e.g. *Osyris tenuifolia*.

Tinctorius, a, um, of or belonging to dyeing, e.g. *Alkanna tinctoria*.

Toxicum, i, arrow-poison, poison; ferro, tuli, latum, ferre, to bear, e.g. *Strychnos toxifera*.

Tuberosus, a, um, full of lumps or protuberances, e.g. *Solanum tuberosum*.

Uncinatus, a, um, hooked, e.g. *Aconitum uncinatum*.

Usitatissimus, a, um, the most usual, most common, e.g. *Linum usitatissimum*.

Uvifer, era, erum, cluster bearing, producing grapes, e.g. *Coccoloba uvifera*.

Variabilis, e, changeable, variable, e.g. *Agathosma variabilis*.

Variego, avi, atum, are, to make of various colours, to variegate, e.g. *Aconitum variegatum*.

Venenum, i, poison, charm, dye, e.g. *Physostigma venenosum*.

Venustus, a, um, graceful, beautiful, e.g. *Barosma venusta*.

- Verus, a, um, true, e.g. *Illicium verum*.
Vesicula, æ, a little bladder, e.g. *Fucus vesiculosus*.
Villosus, a, um, hairy, shaggy, rough, e.g. *Amomum villosum*.
Viminalis, e, of or belonging to osiers, e.g. *Salix viminalis*.
Viridis, e, green, e.g. *Veratrum viride*.
Virosus, a, um, full of or covered with slime, e.g. *Lactuca virosa*.
Vitellina, æ, calf's flesh, veal, e.g. *Salix vitellina*.
Vulgaris, e, common, ordinary, e.g. *Marrubium vulgare*.

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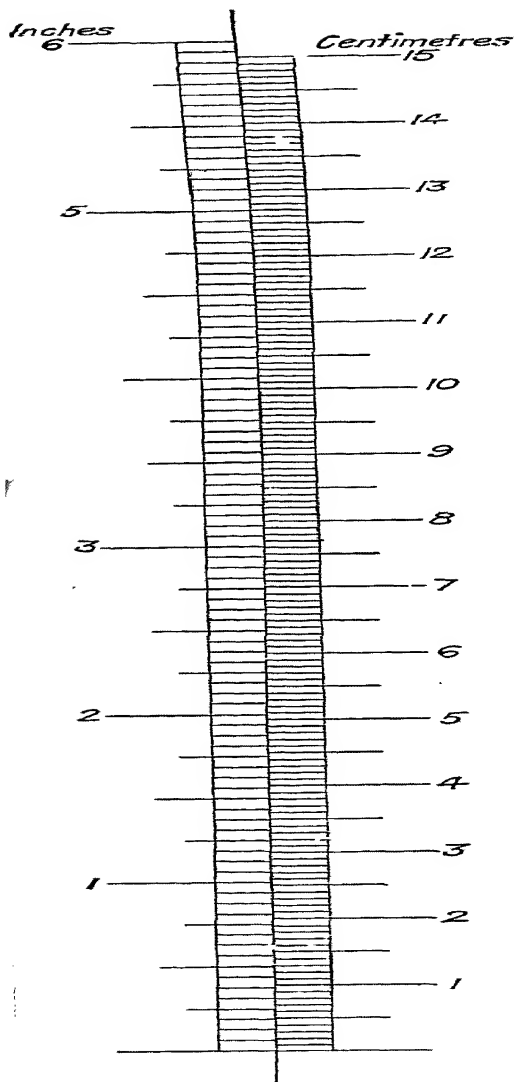
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